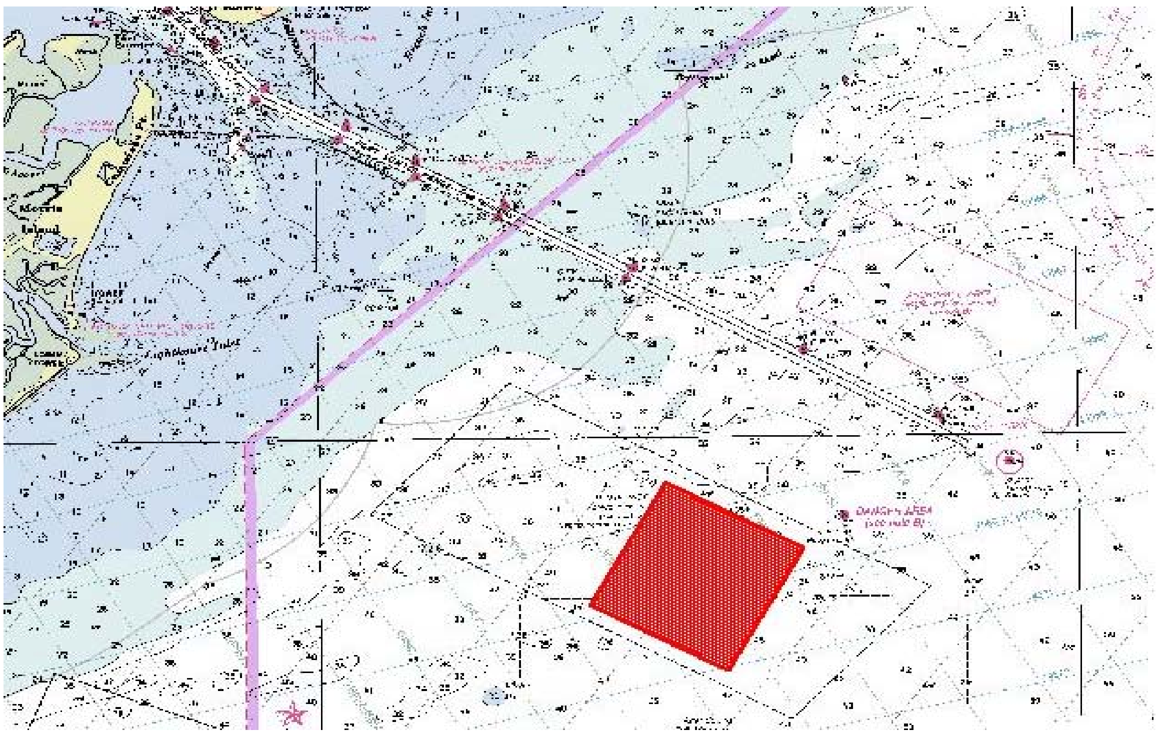
An Environmental Assessment of the Charleston Ocean Dredged Material Disposal Site And Surrounding Areas:

Physical and Biological Conditions after Partial Completion of the Charleston Harbor Deepening Project



Prepared by:
South Carolina Department of Natural Resources
Marine Resources Research Institute

Submitted to:
U.S. Corps of Engineers
Charleston District

FINAL REPORT

An Environmental Assessment
of the
Charleston Ocean Dredged Material Disposal Site
and Surrounding Areas:

Physical and Biological Conditions
After Partial Completion of the
Charleston Harbor Deepening Project

Prepared by:

Lynn E. Zimmerman, Pamela C. Jutte, and Robert F. Van Dolah
Marine Resources Research Institute
South Carolina Department of Natural Resources
P.O. Box 12559
Charleston SC 29422

Prepared for:

U.S. Army Corps of Engineers
Charleston District
69-A Hagood Avenue
Charleston SC 2940

July 2002

TABLE OF CONTENTS

Executive Summary ... ii
List of Figures ... iv
List of Tables ... vi
Introduction ... 1
    Site History ... 1
    Past Monitoring Activities ... 4
        Bathymetry ... 4
        Sediment Characteristics and Sediment Contaminants ... 4
        Biological Communities ... 6
        Hydrographic Data ... 7
        Sediment Mapping Surveys ... 8
    Unauthorized Disposal Activity ... 9
    Interim Monitoring Efforts ... 11
    Present Conditions ... 14
Methods ... 16
    Field Sampling ... 16
    Laboratory Processing ... 18
    Data Analyses ... 20
        Sediment Characteristics ... 20
        Sediment Contaminants ... 21
        Benthic Infaunal Assemblages ... 22
            Spatial Changes ... 27
            Temporal Changes ... 27
Results and Discussion ... 29
    Sediment Characteristics ... 29
        Spatial Comparisons ... 29
        Temporal Comparisons ... 34
    Sediment Contaminants ... 39
    Benthic Infaunal Assemblages ... 40
        Overview---2000 Benthic Data ... 40
        Spatial Changes ... 46
        Temporal Changes ... 49
Conclusions and Recommendations ... 60
Summary ... 62
Acknowledgements ... 67
Literature Cited ... 68

Appendices ... 73
    Station Location and Depth
    Sediment Characteristics
    Benthic Infaunal Data by Station

EXECUTIVE SUMMARY

This report evaluates the physical and biological condition of bottom habitats within and surrounding the Charleston Offshore Dredge Material Disposal Site (ODMDS) approximately halfway through the 1999-2002 Charleston Harbor Deepening Project. Physical and biological conditions summarized in this report include sediment characteristics, sediment contaminants, and benthic assemblages in the disposal zone, inner boundary zone, and outer boundary zone. These results represent a portion of an ongoing, long-term monitoring program. The larger monitoring program also included side scan sonar surveys, sediment mapping surveys, assessments of hard bottom reef communities, and measurements of disposal sediment mobility and transport in the region. Detailed findings from the other portions of the monitoring program are reported elsewhere.

The ODMDS disposal zone and surrounding boundary areas were divided into 20 discrete strata of comparable size, approximately one square mile. Benthic grab samples for sediment characteristics, sediment contaminants, and benthic assemblage analysis were collected at ten randomly selected locations within each of the twenty strata. Sediment characteristics included percent silt/clay, percent sand, percent $CaCO_3$, organic matter content, and grain size of the sand fraction. Sediment contaminants measured were trace metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Benthic assemblage parameters evaluated included total density, number of species, density of general taxonomic groups, and density of numerically dominant taxa. A cluster analysis based on benthic species composition and density was also conducted.

The disposal of fine-grained inner harbor sediments into the Charleston offshore disposal zone has resulted in a number of physical and biological impacts to the area surrounding the disposal zone. Sediment characteristics to the west of the disposal zone are altered relative to typical levels in nearshore South Carolina waters. These changes in sediment characteristics have, in turn, impacted the benthic community living to the west of the disposal zone. Mean density, number of species, density of certain taxon groups, and density of several dominant taxa have been altered in those strata located to the west and northwest of the disposal zone.

The current disposal activities resulted in the placement of fine-grained inner harbor materials in the western and central portions of the disposal zone, while shelly sands from the entrance channel were used to build upon the eastern berm of the disposal zone. As expected, sediment characteristics within the disposal zone were significantly different from those in the boundary zones. Sediment characteristics were also significantly different from earlier baseline sampling conducted in 1993 and 1994. Although disposal effects were intended to be limited to the disposal zone, silt/clay content in the inner and outer boundary zones was significantly higher in 2000 than in baseline studies. This increase in muddy sediments was most evident in the areas to the west of the disposal zone. The probable source of elevated silt/clay levels in the boundary zones is migration of materials from the disposal site or unauthorized dumping of disposal material.

Sediment contaminant levels were low within the disposal zone and surrounding areas. Trace metal, PAH, PCB, and pesticide concentrations were all below published bioeffects guidelines. Contaminant concentrations above the detection limit were found in a number of strata, but highest levels were consistently found in disposal zone sediments. This suggests that the presence of contaminated sediments was low and limited to within the disposal zone.

This report focuses on the condition of benthic infaunal assemblages in the inner and outer boundary zones. Although biological effects within the disposal zone were anticipated, analyses in these areas were limited to sediment characteristics and contaminants in an effort to lower study costs. Cluster analyses revealed that the benthic community structure at impacted areas was distinct from the benthic community structure at non-impacted areas. Benthic infaunal populations within the boundary areas impacted by disposal of dredge materials (i.e. to the west of the disposal zone) showed decreased faunal densities and number of species. Other benthic parameters, such as the density of certain taxonomic groups and the density of dominant taxa, were also altered in areas impacted by disposal activities. Declines in the density of organisms within the disposal area, as well as in surrounding areas, may cause long-term effects due to reduced local recruitment.

Monitoring activities at the disposal site should not cease upon the completion of large-scale disposal operations because these monitoring efforts are needed to document the duration and fate of disposed sediments and long-term trends at the site. Therefore, SCDNR recommends that the planned post-assessment and three-year post-assessment of the Charleston ODMDS and surrounding areas be completed using the same sampling strategies used for the baseline and 2000 surveys. In addition, the continuation of monitoring efforts at hard bottom reef sites, planned through at least spring 2005, is warranted to document the status of biological resources, habitat condition, and areal extent.

Continued monitoring of the Charleston disposal zone and surrounding areas is particularly critical in the face of ongoing disposal operations, future disposal operations, and possible site expansion requests. Based on the data collected during the post-assessment studies, specific recommendations for monitoring in subsequent years of the program may change, and findings may warrant an extension in the length of the monitoring program.

LIST OF FIGURES

Figure 1. Location of larger ODMDS, smaller ODMDS, EPA line, and current four square mile disposal zone 2

Figure 2. Permitted disposal zone within the Charleston ODMDS and the surrounding boundary zones 3

Figure 3. Contour maps of (A) total gamma activity and (B) sediment slurry density (light intensity) in the disposal zone and surrounding boundary areas....13

Figure 4. Location of stations sampled in the disposal zone and surrounding boundary areas as part of the interim assessment 17

Figure 5. Contour map of percent sand of surficial sediments sampled in 2000....30

Figure 6. Contour map of percent shell hash of surficial sediments sampled in 2000....31

Figure 7. Sediment composition of each stratum sampled in 2000....32

Figure 8. Contour map of percent silt/clay of surficial sediments sampled in 2000....33

Figure 9. Mean organic matter content in each stratum sampled in 2000....35

Figure 10. Mean grain size of sand for each stratum sampled in 2000....36

Figure 11. Mean percentage of silt/clay in zones sampled in 1993, 1994, and 2000....38

Figure 12. Percent abundance of general taxonomic groups from grab samples collected in 2000 47

Figure 13. Results of normal cluster analysis using Bray-Curtis similarity coefficient on benthic data collected in 2000....50

Figure 14. Mean benthic density at 1993/1994 reference stations and strata sampled in 2000 52

Figure 15. Mean number of species at 1993/1994 reference stations and strata sampled in 2000 53

Figure 16. Density of general taxonomic groups at 1993/1994 reference stations and strata sampled in 2000 55

Figure 17. Mean density of *Prionospio dayi* at 1993/1994 reference stations and strata sampled in 2000 56

Figure 18. Mean density of *Crassinella martinicensis* at 1993/1994 reference stations and strata sampled in 2000 59

LIST OF TABLES

Table 1. Method detection limits and bioeffect levels for metals tested for in sediments collected in 2000 from the disposal zone and surrounding areas 23

Table 2. Method detection limits and bioeffect levels for organics tested for in sediments collected in 2000 from the disposal zone and surrounding areas ..24

Table 3. Method detection limits and bioeffect levels for PCBs tested for in sediments collected in 2000 from the disposal zone and surrounding areas 25

Table 4. Method detection limits and bioeffect levels for pesticides tested for in sediments collected in 2000 from the disposal zone and surrounding areas ..26

Table 5. Metal concentrations detected in sediment samples collected in 2000 from the disposal zone and surrounding areas...41

Table 6. Organic compound concentrations detected in sediment samples collected in 2000 from the disposal zone and surrounding areas.......................................42

Table 7. PCB concentrations detected in sediment samples collected in 2000 from the disposal zone and surrounding areas...43

Table 8. Pesticide concentrations detected in sediment samples collected in 2000 from the disposal zone and surrounding areas..44

Table 9. The numerically dominant benthic taxa collected in 2000 from the disposal zone and surrounding areas...45

INTRODUCTION

Site History

The Charleston, South Carolina, Ocean Dredged Material Disposal Site (ODMDS) is actively used by the U.S. Army Corps of Engineers to receive bottom sediments dredged from channel maintenance and deepening projects in the Charleston Harbor estuary. The configuration of this ODMDS has changed over the past 15 years with respect to the location and size of the areas where recent disposal operations have occurred (Van Dolah *et al.* 1996, 1997; Winn *et al.* 1989). Authorized disposal activities have taken place within a larger area that encompassed approximately 5.3 x 2.3 nautical miles (Figure 1, labeled "larger ODMDS"). Prior to the current location, a 2.8 x 1.1 nautical mile site (Figure 1, labeled "old disposal area") was used until it was discovered that dumping operations were impacting a live bottom area within the western quarter of that area. In 1993, an interagency Task Force identified a new location four square miles in size that was located in the outer portion of the larger ODMDS for disposal of future materials. A Management Plan for this ODMDS included a comprehensive monitoring plan for the site that is described in the Charleston ODMDS Site Management and Monitoring Plan (1993). The four square mile disposal zone and surrounding areas were divided into three zones representing the disposal zone, inner boundary zone, and outer boundary zone (Figure 2), which were further subdivided into 20 discrete strata of comparable size (one square mile). Based on the Site Management and Monitoring Plan, the U.S. Army Corps of Engineers (USACE) began building an L-shaped berm on the western side of the four square mile disposal zone using material from the 1991-1996 deepening project. The berm was to be constructed of harder materials and was designed

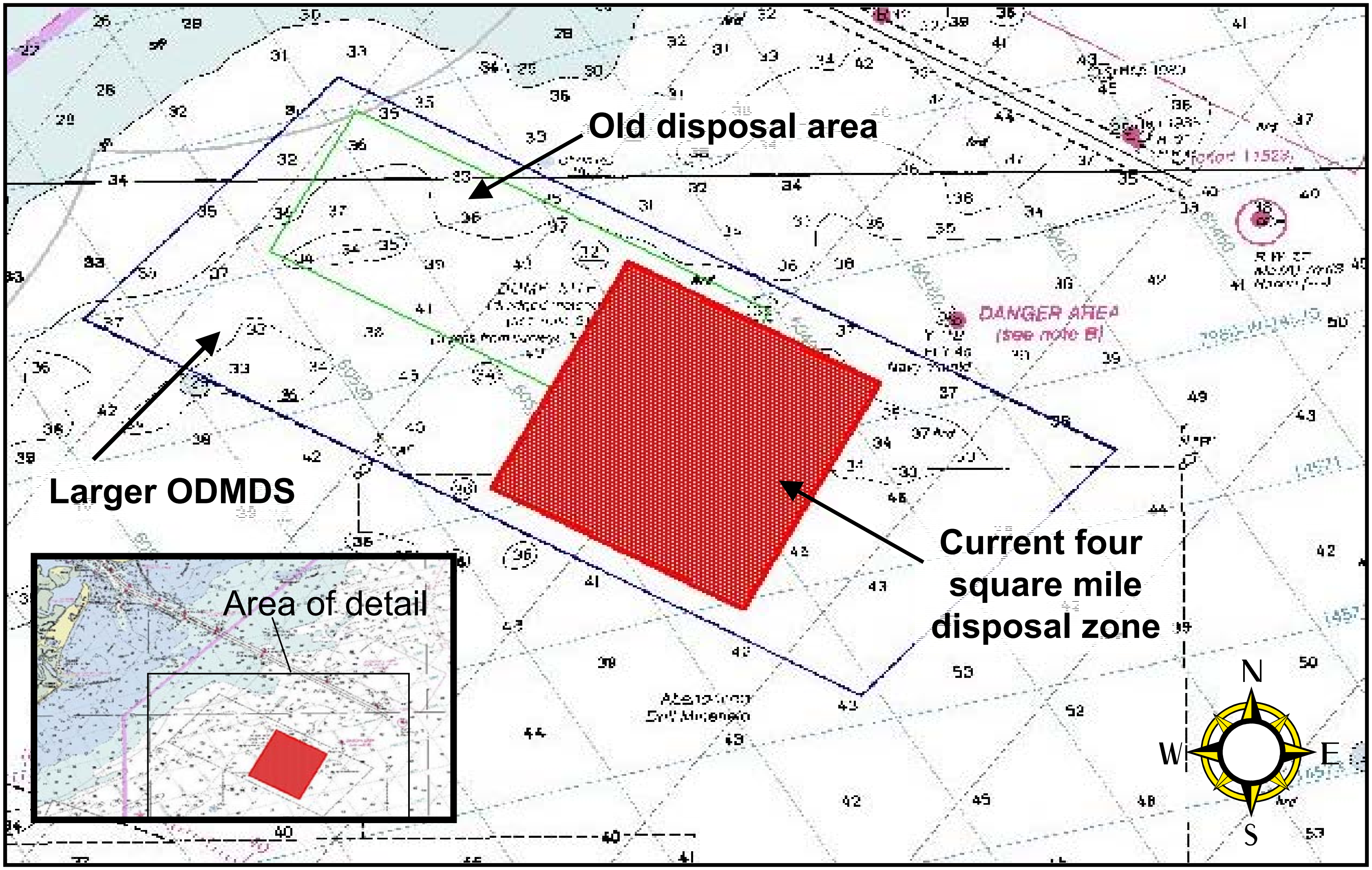


Figure 1. Location of the larger ODMDS (blue box), old disposal area (green box), and current four square mile disposal zone (red box). See text for details.

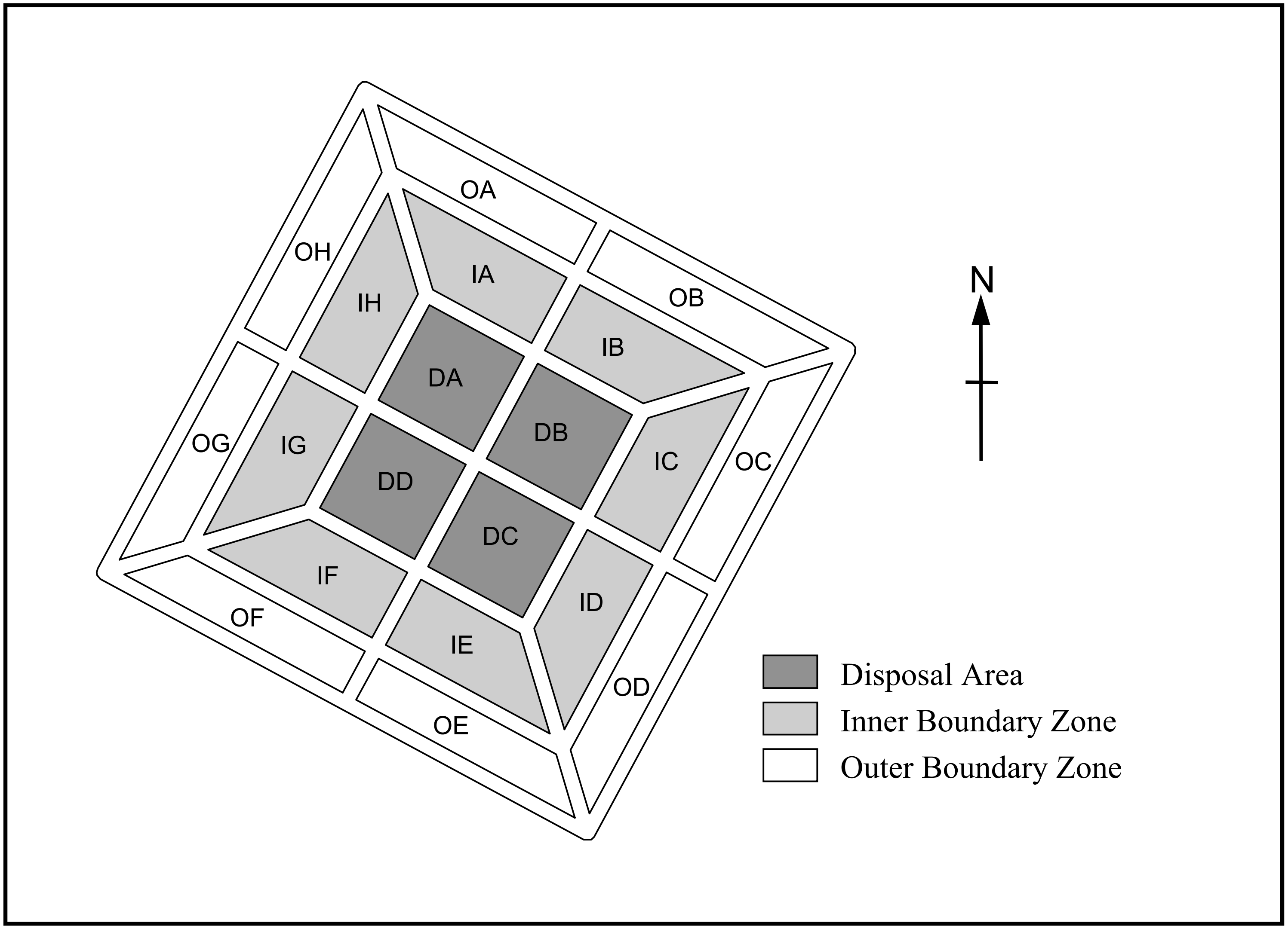


Figure 2. Permitted disposal zone within the Charleston ODMDS and the surrounding boundary zones.

to serve as a barrier, with finer materials to be placed to the east of the barrier.

The U.S. Congress authorized the most recent Charleston Harbor Deepening Project in 1996. The project was initiated in July 1999, and completed in April 2002. The project was planned to deepen the entrance channel from 42 ft to 47 ft, and the inner harbor channel from 40 ft to 45 ft. Approximately 20-25 million cubic yards of sediments were planned for disposal in the four square mile disposal zone selected by the Task Force in 1993.

Past Monitoring Activities

Extensive monitoring of the Charleston ODMDSs has occurred throughout the years. These efforts have included bathymetric surveys, analyses of sediment characteristics and sediment contaminant levels, assessments of biological communities, hydrographic surveys, and areal mapping of sediment chemistry. The following sections describe these efforts by type.

Bathymetry

Detailed bathymetric monitoring of the smaller ODMDS and surrounding area has been conducted by the USACE at periodic intervals since 1972 to: (1) document the location and configuration of mounds created by placing dredged material along narrow corridors within the smaller ODMDS, and (2) determine whether these mounds were remaining stable (Winn *et al.* 1989).

Sediment Characteristics and Sediment Contaminants

Monitoring of bottom sediment characteristics and sediment contaminant levels in the area was first completed in 1978 (Winn *et al.* 1989) by the South Carolina

Department of Wildlife and Marine Fisheries (SCWMRD, now the South Carolina Department of Natural Resources). That study provided sedimentological data at 40 sites, and contaminant data at 24 sites in and around the larger ODMDS (SCWMRD 1979, Van Dolah *et al.* 1983). Interstate Electronic Corporation (IEC) sampled sediments at 10 sites and contaminant levels at 10 sites in the area of the larger ODMDS during 1979 (EPA 1983). These studies did not find elevated levels of contaminants. The SCWMRD study found higher levels of mercury and cadmium than the IEC study, which may have been due to analytical methodology (EPA 1983).

Winn *et al*. (1989) collected sediment and sediment contaminant samples at 28 sites in the larger ODMDS and surrounding areas. None of the stations displayed contaminant levels above the range observed in the 1978 SCWMRD study. Minor changes in sediment characteristics were detected, with some movement of material away from the disposal site. Surficial sediment characteristics outside the disposal site did not appear to be altered.

As part of the baseline assessment of the current four square mile disposal zone, 200 sediment samples were collected in both 1993 and 1994 in and around the disposal zone (Van Dolah *et al*. 1996, 1997). Bottom sediments in the area were comprised primarily of medium to fine-grained sands, with variable concentrations of silt/clay and shell hash. Relatively high concentrations of mud (>10%) were found within the disposal area in 1993. By 1994, most of the muddy sediments had dispersed. Forty composite sediment contaminant samples were also collected during the 1993-1994 assessment. Metal contaminants were detected in several strata, but concentrations were generally below known bioeffects levels.

Biological Communities

Benthic assemblages in the vicinity of the larger ODMDS have been monitored since 1978. SCWMRD (1979) completed an assessment in 1978. No major differences were found in the benthic communities collected within the larger ODMDS compared to adjacent areas (Van Dolah *et al.* 1983). The IEC sampled the benthos at 10 sites during March and December 1979 in the vicinity of the larger ODMDS (EPA 1983). Their findings also did not indicate any differences in the benthic communities present, which could be attributed to previous disposal operations.

An updated assessment was completed in 1987 by the SCWMRD due to the changes in the site designation that occurred at that time (Winn *et al.* 1989). The benthic sampling program was designed around the corridor disposal concept with a network of stations positioned to intercept the migration of material over the bottom, if it occurred, and to assess changes in the benthic communities resulting from the movement of dredged material. The 1987 baseline survey detected minor changes in benthic community structure related to a disposal operation completed in 1986, and some movement of the material was detected away from the disposal site (Winn *et. al*. 1989). However, this movement did not appear to significantly alter benthic communities outside the smaller ODMDS.

The South Carolina Department of Natural Resources (SCDNR) completed intensive benthic infaunal sampling in the four square mile disposal zone and surrounding boundary areas in 1993-94 as part of a baseline assessment of the area (Van Dolah *et al*. 1996, 1997). During this period, they collected benthic samples at 200 stations each year in 20 zones located within and around the current disposal site. Species composition, faunal density, and number of species varied among zones and strata. The density of some general taxonomic groups was found to be related to sediment type, a finding which suggests that future large scale disposal operations could lead to disposal-related changes in the benthic communities.

Several additional studies of demersal fishes and decapods have been conducted in the South Atlantic Bight since the early 1970's. Some of these studies have included one or more sites in the vicinity of the ODMDSs (Wenner *et al.* 1979, 1980; Wenner and Read 1981).

In July 1992, EPA, in conjunction with the University of Georgia's Department of Ecology, undertook a study on the physiological effects of dredged material on the oxygen metabolism of *Oculina arbuscula* (scleractinian) and *Lophogorgia hebes* (gorgonian). The results of the study suggest that while coral recovery from single episodes of low-level sediment exposure is likely, recovery from repeated low level exposures or single episodes of high-level exposure becomes more difficult (Porter 1993). Both long-term responsiveness and immediate short-term productivity rates were inhibited by exposure to sediment concentrations above 100 mg/l (15 NTU) (Porter 1993).

Hydrographic Data

Hydrographic data has been collected as part of most assessments of the Charleston ODMDSs. In 1978, SCWMRD collected hydrographic data at 40 sites during their August sampling effort (SCWMRD 1979). The IEC assessment in 1979 provided additional hydrographic data for the larger ODMDS in the March and December sampling seasons (EPA 1983). Water quality data were collected by SCWMRD in 1987 during the summer and winter (Winn *et al.* 1989). Hydrographic data were also collected by SCDNR during summer sampling periods in 1993 and 1994 (Van Dolah *et al*. 1996, 1997).

Data on ocean currents at the Charleston ODMDSs were collected by EPA in summer and winter 1991, and NOAA also collected a limited number of observations in the seaward reaches of the Charleston Harbor Entrance Channel (Wilmot 1988). The ocean current data were used by the Corps of Engineers, Waterways Experiment Station (WES) for input into a model simulating sediment plume dispersion for a dumping episode at the site. Ocean current data revealed a predominant NNE component during the summer. While the strong NNE component was also present during the winter, a westerly component was evident during that season as well. Currents toward the southern, and neighboring sectors, were minimal during these sampling periods.

The National Ocean Service (NOS), Coastal Estuarine and Oceanography Branch (CEOB) deployed a 1200 kHz acoustic Doppler current profiler (ADCP) in the larger ODMDS from January 1994 through September 1995 in an effort to measure ocean currents in the vicinity of the site. The results of this study found that the currents in the vicinity of the Charleston ODMDSs consist of tidal, wind-driven, and density-driven currents. The currents flowing toward the southwest or west could potentially transport dredged material to the benthic communities in the southwest corner of the larger ODMDS (Williams *et al.* 1997).

Sediment Mapping Surveys

To assist in defining dredged material placement and migration within the Charleston Harbor ODMDSs, real time mapping of the seafloor sediments in the

Charleston ODMDS and surrounding areas has been conducted by the USEPA and the Center for Applied Isotope Studies at the University of Georgia (Noakes 1995). The gamma isotope mapping system (GIMS) tows a sled with gamma radiation detection capability and uses these data to map identify the chemical signature and distribution of sediments. The continuous sediment sampling system (CS^3) uses a sled-mounted submersible pump to collect surficial sediments, which are later analyzed using x-ray fluorescence spectroscopy. Sites were mapped along transects spaced approximately 1,000 feet apart.

The EPA, in conjunction with the University of Georgia's Center for Applied Isotope Studies (CAIS), completed a survey within the smaller ODMDS site in July 1988, and within the larger ODMDS site in March 1990. Survey results indicated the seafloor within the smaller site was relatively homogeneous, from a selected gamma isotope perspective, and relatively void of fine sediments since the CS^3 sled, which is selective to sediments generally smaller than 400 microns, did not retrieve any material. The larger site was mapped again in August 1991, May 1993, and June 1994. Each of these surveys was successful in tracking and documenting the dispersion of the dredged material deposited at the disposal site. The construction of the L-shaped berm was clearly indicated, as well as other areas of elevated silt/clay concentrations due to historical disposal operations or unidentified origins (Noakes 1995).

Unauthorized Disposal Activity

Based on reports from commercial shrimpers (January 2000), SCDNR staff investigated muddy areas found outside the four square mile disposal zone in 2000.

SCDNR sampling confirmed that sediments high in silt/clay content were present in areas surrounding the four square mile disposal zone, and identified this problem to the USACE, who reviewed logs and found unauthorized dumps made outside the four square mile disposal zone. Reconnaissance of about 50 unauthorized dump sites was completed by a subcontractor to the dredging company and reviewed by SCDNR staff. At least one of the unauthorized dump sites appeared to have occurred over live bottom, and other dumps may also have occurred over other live bottom areas. If so, the bottom and evidence of reef growth were completely buried by the unauthorized dumps. A report summarizing these findings (Jutte *et al.* 2001) was sent to USACE, the contractor (Norfolk Dredging Company), and USEPA.

During the March 2000 Site Management and Monitoring Plan (SMMP) meeting, the USACE noted that the berms under construction at the disposal zone were being built with a mixture of materials, rather than the more consolidated materials as originally planned. It was agreed that future barge loads of material would be assessed by the subcontractor, with more consolidated materials (e.g. cooper marl, rocky material) being placed on the berm, and finer, unconsolidated, materials placed to the southeast of the berm. The SMMP Team also discussed the path of barge traffic over live bottom reef habitat en route to the disposal zone. Team members agreed that by traveling a northerly track to the shipping channel, the potential for accidental dumps over live bottom reefs could be reduced or eliminated.

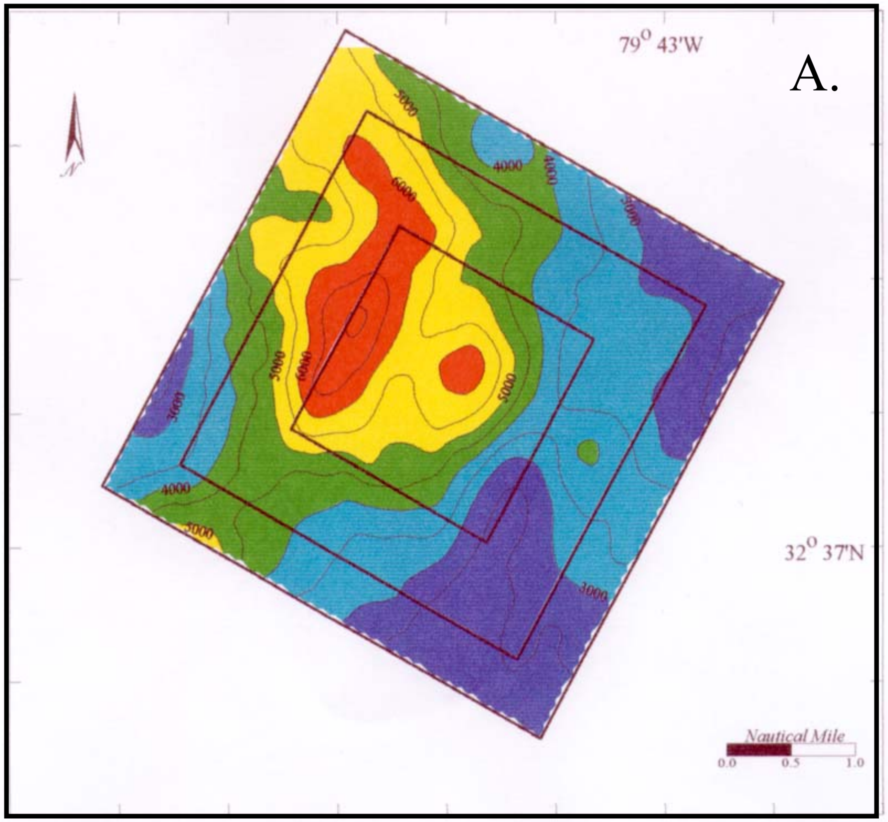
Interim Monitoring Efforts

An interim assessment of the disposal area and surrounding boundary areas was planned to occur approximately halfway through the current Charleston Harbor Deepening Project. This report summarizes the findings of the biological, sediment, and sediment contaminant conditions which were sampled in 2000 as part of this interim assessment.

In March 2000, Coastal Carolina University's Center for Marine and Wetland Studies (CMWS), in cooperation with the U.S. Geological Survey (USGS), completed a side scan sonar survey, swath bathymetry survey, and CHIRP sub-bottom profiling of the disposal zone and surrounding areas. Bathymetry data from the CMWS-USGS survey is presented in this report (see Gayes 2001 for details). Additional closely spaced side scan sonar surveys and bottom video tows were completed in August 2000 at hard bottom reef areas. These data, in addition to direct diver observations, were used to identify areas where disposal material deposited in the disposal zone had been reworked and transported away from the site (Gayes 2001). The side scan imagery detected evidence of curvilinear bands of high backscatter sediments indicative of sediment trailing out of the disposal dredges as they entered or exited the disposal zone, as well as numerous dredge dump deposits in the boundary areas outside the designated disposal zone.

The second survey season (July-August 2001) produced an updated regional side scan sonar mosaic that extended further offshore than the March 2000 survey (Gayes *et al.* 2002). When these two side scan sonar mosaics were compared, new unauthorized dumps outside the boundaries of the disposal zone were apparent that must have occurred since the March 2000 survey was conducted. During the same research cruises, detailed video and side scan sonar surveys at the index reef sites were also collected. A new application of a textural analysis routine and neural network classifier developed by CMWS staff indicated that approximately 53% of the surface area of each of the six 1-km^2 index reef sites was composed of hard bottom. Temporal data were available for only one reef site, located in the outer boundary zone southwest of the disposal zone. The analysis technique indicated that this reef site may have experienced a loss in hard bottom habitat between March 2000 and July 2001 (Gayes *et al.* 2002). Additional sampling will further investigate change in hard bottom at these sites, and refine estimates of hard bottom loss. The change in areal extent of the reef habitat at this site appears to be caused by some combination of the effects of disposal activities and natural variability, but the relative effects of each causal factor cannot be identified until additional data are collected. Further information on these research cruises and details on the remainder of the geophysical data are presented in Gayes *et al*. (2002).

Areal mapping of sediment chemistry was conducted by the University of Georgia's Center for Applied Isotope Studies in October 2000 (Noakes 2001). The goal of the mapping survey was to track sediment and sediment movement patterns in and around the disposal zone using the gamma isotope mapping system (GIMS) and the continuous sediment sampling system (CS^3). Noakes (2001) reported that misplaced dredged material was clearly indicated in the western region outside the disposal area (Figure 3). In addition, a trail of probable dredged material was observed leaving the western disposal cell (strata DA, Figure 2) heading towards the northwest; the trail observed was most likely the result of dredged material falling from disposal barges as they entered or existed the disposal zone (Noakes 2001).



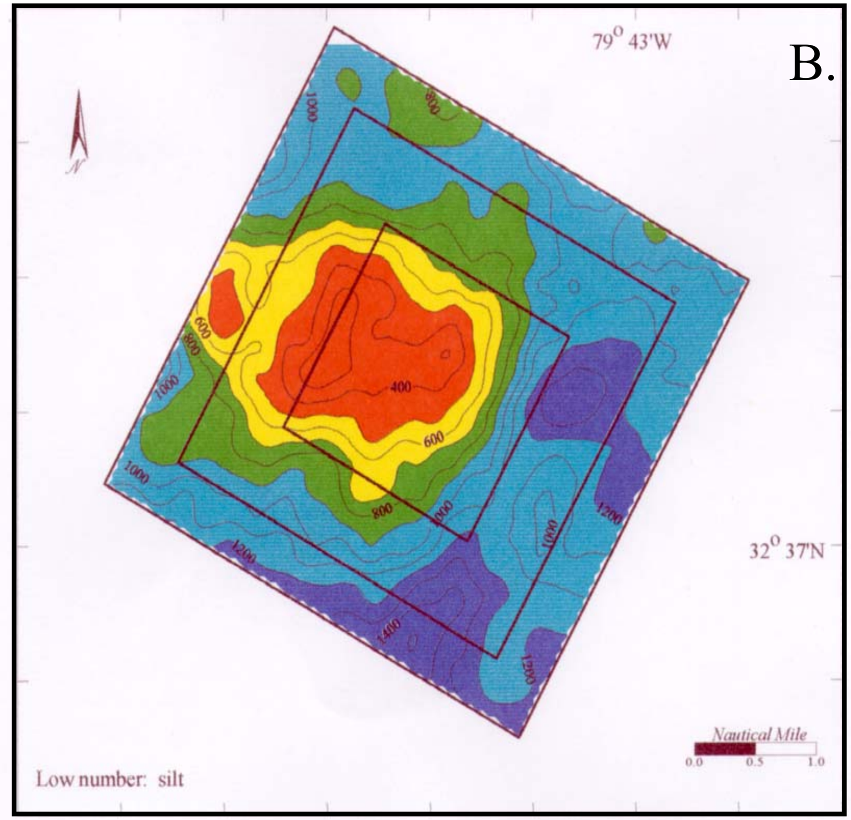


Figure 3. Contour maps of (A) total gamma activity and (B) sediment slurry density (light intensity) for the disposal zone and surrounding areas. Total gamma activity is reflecting the marl being dredged from the harbor which is high in ^{214}Bi (phosphate) and ^{40}K (clay). There is extremely good agreement between the harbor dredged material placed in the western berm area and the total gamma activity. Sediment slurry density gives a good quantitative evaluation of the amounts of surficial fine-grained sediment on the seafloor. Figures from Noakes (2001).

An assessment of disposal material mobility and transport in the vicinity of the disposal site was conducted by the University of South Carolina Coastal Processes and Sediment Dynamics Laboratory (Voulgaris 2002). The combined action of waves and currents were measured for 35 days using a bottom-mounted platform deployed to the west of the western berm of the disposal site (strata IG, see Figure 2 for location) and equipped with an acoustic doppler current profiler and optical backscatter sensor. In general, it was found that the combined shear stress by the waves and currents is much larger than the mean currents alone. Comparison of the mean stresses with the settling characteristic of the sediments suggest that the finer-grained dredged material can create flocculates that have reduced settling velocities. Therefore, finer-grained dredged material can be transported even with the slightest wave conditions.

Four hard bottom reef study sites and two control reefs have been surveyed three times to date (fall 2000, spring 2001, fall 2001). During each sampling period, video surveys of sponge/coral communities, video surveys of fish communities, and measurements of surficial sediment depths, surficial sediment characteristics, and sedimentation rates were collected. In addition, a detailed side scan sonar survey with simultaneous underwater video was completed annually to determine changes in the areal extent of each reef site (details in previous section). Biannual assessments of these index hard bottom reef sites will continue through at least spring 2005.

Present Conditions

The monitoring efforts conducted in the vicinity of the permitted disposal zone within the Charleston ODMDS clearly document a trend of fine materials migrating from the disposal zone in a predominately westerly direction, compounded by unauthorized disposal activities in the west/southwest region of the boundary areas, and dredge trailings to the northwest of the site. Based on these findings, we cannot differentiate whether the disposal material is moving from the disposal site over the berms, from the berms, from unauthorized disposal activities that occurred in 1999-2001, from the dispersion of the material during disposal activities at the site, or some combination of all four possibilities. In addition, due to the long-term use of the site, it is difficult to distinguish between the effects of recent and historical disposal activity. Regardless, for the purposes of this report, data collected to date strongly support the contention that existing conditions to the west, southwest, and northwest of the disposal zone have been impacted. The boundary zones east of the disposal site remain similar to conditions before dredging began.

METHODS

Field Sampling

Sampling efforts took place within the permitted disposal zone in the Charleston ODMDS (Federal Register 67 FR 30597) and the inner and outer boundary zones defined as part of the 1993-94 baseline assessment of the Charleston ODMDS (Van Dolah *et al*. 1997). These three zones (disposal, inner, and outer) are composed of a total of 20 discrete strata of comparable size, approximately one square mile (Figure 2). A 100 m buffer was created inside the boundary of each stratum to avoid the inadvertent location of sampling sites in adjacent strata. Positioning at sites sampled within each strata was accomplished using a Geographic Positioning System (GPS) equipped with a differential beacon. Sampling was completed on September 11-12, 2000 using the SCDNR R/V Lady Lisa.

One benthic grab sample was collected at 10 sites within each of the 20 strata using a 0.043 m^2 Young grab. Stations sampled in 2000 were selected from the original random array of 400 stations sampled in 1993 and 1994. The location of sites sampled in 2000 is shown in Figure 4, and the latitude/longitude coordinates for each site (NAD83 datum) are provided in Appendix 1. Each grab sample was sub-sampled for analysis of sediment characteristics (% sand, silt, clay, $CaCO_3$; organic matter content; sand grain size distribution), and for the presence of contaminants. The core used to characterize sediments was collected using a plastic tube (3.5 cm dia.) inserted through the top of each grab to the bottom of the sample. Sediment characteristics samples were stored separately for each grab sample. The sediment contaminant core was collected using a stainless steel tube (2.5 cm dia.) first rinsed with acid (0.1 N HCl) and hexane, and then

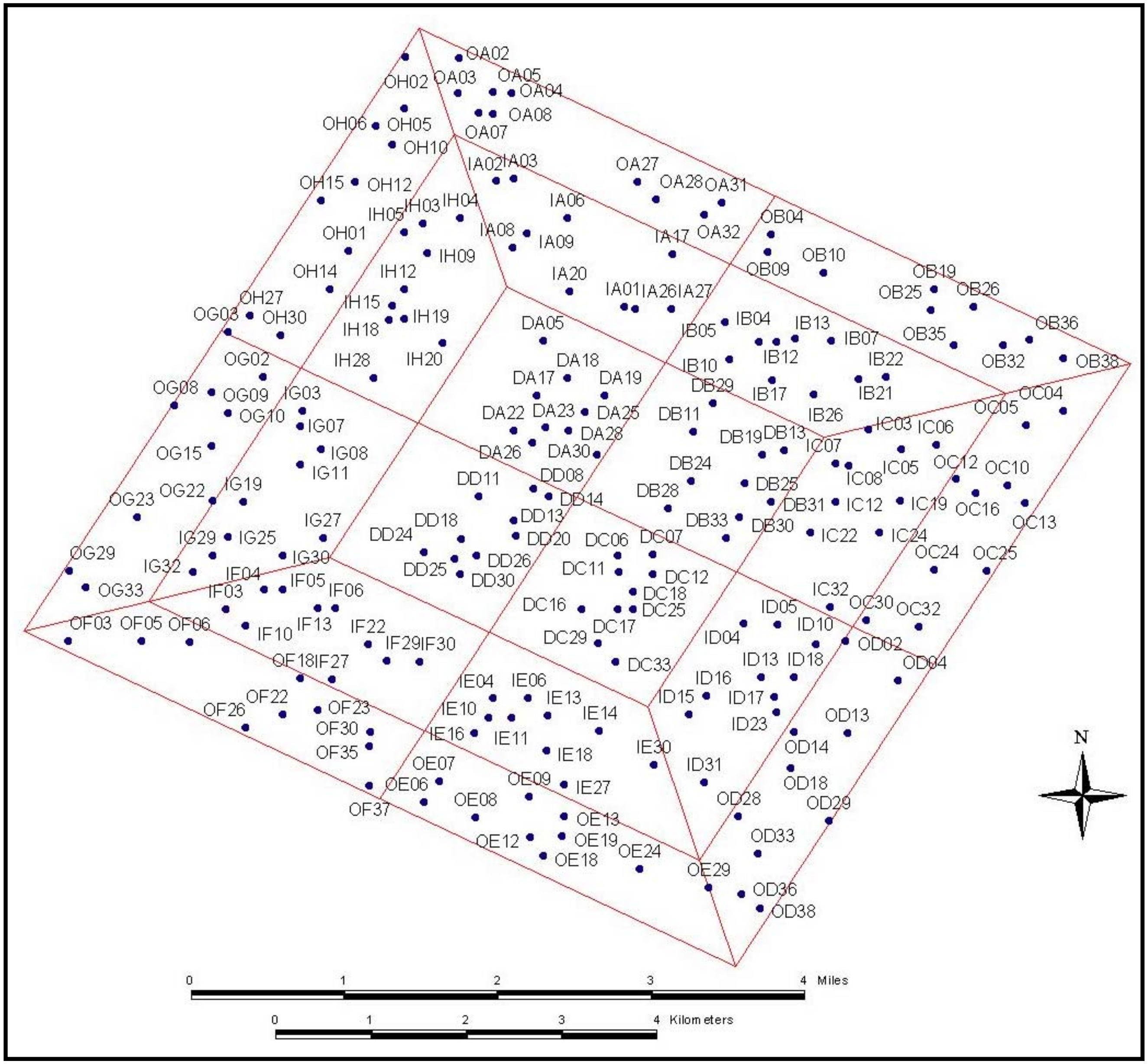


Figure 4. Location of stations sampled in the disposal zone and surrounding boundary areas as part of the interim assessment. Samples were collected on September 11-12, 2000. See text for details.

inserted through the top of the grab sample at least 1 cm away from the sides of the grab. Contaminant cores collected from each of the 10 sites sampled within a stratum were composited and transferred to pre-cleaned glass jars with Teflon lids. All contaminant samples were stored on ice or at 4°C until they were processed in the laboratory. The remainder of the grab sample, representing approximately 0.04 m^2 of bottom surface area, was washed through a 0.5 mm-mesh sieve. Organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin/seawater with rose bengal stain.

Laboratory Processing

Sediment composition, mean grain size, and total organic carbon (TOC) were analyzed in all samples collected (n = 200). The sediment composition samples were analyzed for percentages (by weight) of sand, silt, clay, and calcium carbonate ($CaCO_3$) using procedures described by Folk (1980) and Pequegnat *et al.* (1981). Sand fractions were dry-sieved using a Ro-tap mechanical shaker and grain size was determined using fourteen 0.5 phi-interval screens, where phi = $-\log_2$ (grain diameter in mm) according to the Udden-Wentworth Phi classification (Brown and McLachlan 1990). TOC was measured on a Perkin Elmer Model 2400 CHNS Analyzer. The CHNS Analyzer determines the percent organic matter present in a subsample of sediment.

Contaminants measured in the sediments included 14 metals, 25 PAHs, 27 PCBs, and 22 pesticides. Sediment contaminant analyses were completed for all composite samples (n = 20). All contaminants were analyzed by the NOAA-NOS Coastal Center for Environmental Health and Biomolecular Research (CCEHBR) using the following protocols. Extraction and sample preparation for organic compounds were similar to those described by Krahn *et al*.(1988) and Fortner *et al.* (1996). Samples were then extracted with CH_2Cl_2 using accelerated solvent extraction, concentrated by nitrogen blow-down, and cleaned by gel permeation chromotography where necessary. PAHs were quantified by capillary GC-ion trap mass spectrophotometry. Organochlorine pesticides and PCBs were analyzed using dual column gas chromatography with electron capture detection using methods described by Kucklick *et al*. (1997). Trace metals were analyzed using methods similar to those described by Long *et al.* (1998) using inductively coupled plasma spectroscopy for Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sn, Zn and by graphite furnace atomic absorption for Ag and Se. Mercury was analyzed by cold-vapor atomic absorption. The analytical method detection limits as well as bioeffects limits for the various contaminant analytes are listed in Tables 1-4.

Benthic infaunal sample sorting and taxonomic identification were completed using a tiered approach. Samples were processed from a selected subset of strata collected in boundary areas known to be impacted based on findings from other studies conducted as part of the interim assessment (Noakes 2001, Gayes 2001, Gayes *et al*. 2002). These samples were then compared with samples from another subset of strata collected from the boundary zones where there was no evidence of change in sediment condition. Impacted strata included IA, OA, IG, OG, IH, and OH (n = 60 grab samples), and non-impacted strata included IC, OC, ID, and OD (n = 40 grab samples). Benthic samples were sorted in the laboratory to remove the organisms from sediments remaining in the sample. All organisms were then identified to the species level, or the lowest practical level possible if the specimen was damaged or incomplete. A master voucher collection was created for the project and will be maintained by the Environmental Research Section at SCDNR.

Data Analyses

Sediment Characteristics

The analytical techniques used to process organic carbon measures in 2000 were different from those used in 1993-1994 baseline studies. As described above, sediments collected in 2000 were analyzed using a CHNS analyzer. In 1993 and 1994, sediments were analyzed for organic matter content by burning a portion of each sample at 550^{o}C for two hours as described by Plumb (1981). These techniques both determine the percent of a subsample of the core sediment sample that is comprised of organic matter. Although, both techniques provide a measure of how much organic matter occurs in the sediments, the different analytical techniques mean that these data are not directly comparable. Previous work conducted by Ringwood *et al.* (1995) analyzing estuarine sediment samples collected in the Carolinian Province (Virginia, North Carolina, South Carolina, Georgia, and Florida) showed that there was a strong correlation ($r^2 = 0.98$, $p < 0.001$) between the two analytical techniques. To determine if a similar correlation existed for offshore sediments, a subset of the sediment samples collected in 2000 for the present study were reanalyzed using the same technique used for 1993-1994 samples. A subset of 50 sediment samples collected in 2000, including samples with high silt/clay content (n = 17), moderate silt/clay content (n = 16), and low silt/clay content (n = 17), were analyzed. The comparison resulted in a high level of correlation ($r^2 = 0.96$, $p <$

0.0001) between results generated from the two analytical techniques, and the resulting linear regression was used as a conversion tool for the 2000 data.

Sediment characteristics were analyzed to determine differences among the three zones (disposal, inner boundary and outer boundary) as well as between strata. One-way analyses of variance (ANOVA) were performed on rank-transformed data using Sigmastat for Windows version 2.03 (SPSS 1997). To evaluate temporal changes in sediment characteristics, two-way ANOVAs comparing either year and zone or year and strata were performed. Sediment characteristics (% sand, % silt/clay, % $CaCO_3$, organic matter content, and mean phi size) from 2000 were statistically compared to 1993 and 1994 sediment data. Analyses were performed on rank-transformed data using Sigmastat for Windows version 2.03 (SPSS 1997).

Sediment Contaminants

Sediment contaminant data from 2000 were summarized in tabular form. For many of these contaminants, Long *et al.* (1995) published bioeffects guidelines that reflect the concentration of a contaminant that resulted in adverse bioeffects in 10% of the studies examined (defined as Effects Range-Low or ER-L) as well as the concentration that resulted in adverse effects in 50% of the studies (defined as Effects Range-Median or ER-M). MacDonald *et al*. (1996) also published bioeffects guidelines designated as threshold effects level (TEL) and probable effects level (PEL). "A TEL was derived by calculating the geometric mean of the 15th percentile of the effects data set and the 50th percentile of the no effects data set. Similarly, a PEL was developed for each chemical by determining the geometric mean of the 50th percentile of the effects data set and the 85th percentile of the no effects data set" (MacDonald *et al*. 1996).

Contaminants concentrations from 2000 data were compared whenever possible to these TEL, PEL, ER-M and ER-L values (Tables 1-4).

As part of the quality assurance for the laboratory analyses of sediment contaminants, standards for each contaminant were analyzed for percent recovery. The majority of contaminants had percent recoveries within the accepted range (70-130%). However, three pesticides (Hexachlorobenzene, 2,4-DDE, and 4,4-DDE), one PAH (Fluorene) and five PCB's (congeners 18, 105, 138, 187, and 195) had percent recoveries below the accepted range, and the pesticide 2,4-DDD and PCB 128 had percent recoveries above the accepted range. Results for these contaminants should be viewed with caution because reported values may not be an accurate estimate of the actual concentrations.

Benthic Infaunal Assemblages

The original benthic infaunal data set for this study was reviewed to eliminate taxa that were not considered representative of the infaunal community. These included epifaunal species that require hard substrate, taxa that are typically considered to be meiofauna, and taxa that are colonial life forms. This deletion applied across all stations, and these species were not considered further in any of the data analyses.

The data set was further reviewed by grab to identify taxa that may potentially over-represent the number of species found in a grab sample. Organisms identified at the family level as well as at the species level within that family, or species identified at a known species level and an unknown species level in the same genus, might represent an inflation of species diversity indices (e.g. Ampeliscidae and *Ampelisca abdita,* or

Table 1. Metals tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported in parts per million dry weight for all metals except aluminum and lead which are reported in percent.

Metals	Minimum Detection Limit*	ERL	TEL	ERM	PEL
Aluminum	0.00002				
Arsenic	0.003	8.2	7.2	70	41.6
Cadmium	0.001	1.2	0.7	9.6	4.2
Chromium	0.03	81	52.3	370	160
Copper	0.01	34	18.7	270	108
Iron	0.00005				
Lead	0.002	46.7	30.2	218	112
Manganese	0.01				
Mercury	0.004 - 0.006	0.15	0.13	0.7	0.7
Nickel	0.002	20.9	15.9	51.6	42.8
Selenium	0.03				
Silver	0.02	1	0.7	3.7	1.8
Tin	0.0040 - 0.005				
Zinc	0.3	150	124	410	271

* Some minimum detection limits vary over a range of values due to variability in sample volume.

Table 2. Organic compounds tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

Organic compound	Minimum Detection Limit*	ERL	TEL	ERM	PEL
1,6,7 Trimethylnaphthalene	1.58 - 1.86				
1-Methylnaphthalene	3.39 - 3.99				
1-Methylphenanthrene	3.13 - 3.68				
2,6 Dimethylnaphthalene	3.16 - 3.71				
2-Methylnaphthalene	4.66 - 5.48	70	20.2	670	201
Acenaphthene	5.46 - 6.42	16	6.71	500	88.9
Acenaphthylene	1.42 - 1.67	44	5.87	640	128
Anthracene	2.92 - 3.44	85.3	46.9	1100	245
Benzo(a)anthracene	6.44 - 7.58	261	74.8	1600	693
Benzo(a)pyrene	8.18 - 9.62	430	88.8	1600	763
Benzo(b)fluoranthene	4.99 - 5.87				
Benzo(e)pyrene	3.78 - 4.44				
Benzo(g,h,i)perylene	5.12 - 6.03				
Benzo(j+k)fluoranthene	4.27 - 5.02				
Biphenyl	5.33 - 6.27				
Chrysene+Triphenylene	1.84 - 2.16				
Dibenz(a,h+a,c)anthracene	1.37 - 1.61				
Dibenzothiophene	2.09 - 2.46				
Fluoranthene	3.60 - 4.23	600	113	5100	1494
Fluorene	2.36 - 2.77	19	21.2	540	144
Indeno(1,2,3-cd)pyrene	7.95 - 9.34				
Naphthalene	8.49 - 9.98	160	34.6	2100	391
Perylene	4.76 - 5.60				
Phenanthrene	2.82 - 3.32	240	86.7	1500	544
Pyrene	2.64 - 3.10	665	153	2600	1398
Total_PAH		4022	1684	44792	16770

* Minimum detection limits vary over a range of values due to variability in sample volume.

Table 3. PCBs tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

PCB Congener	Minimum Detection Limit*	ERL	TEL	ERM	PEL
PCB 101	0.1				
PCB 104	0.1				
PCB 105	0.12				
PCB 118	0.07				
PCB 126	0.13				
PCB 128	0.07				
PCB 138	0.18				
PCB 153	0.1				
PCB 154	0.1				
PCB 170	0.16				
PCB 18	0.15				
PCB 180	0.11				
PCB 187	0.05				
PCB 188	0.1				
PCB 195	0.12				
PCB 201	0.1				
PCB 206	0.098				
PCB 209	0.1				
PCB 28	0.19				
PCB 29	0.1				
PCB 44	0.05				
PCB 50	0.1				
PCB 52	0.07				
PCB 66	0.06				
PCB 77	1.5				
PCB 8	0.13				
PCB 87	0.1				
Total_PCB		22.7	21.6	180	189

Table 4. Pesticides tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al.* (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

Pesticide	Minimum Detection Limit	ERL	TEL	ERM	PEL
2,4'-DDD	0.06				
2,4'-DDE	0.06				
2,4'-DDT	0.14				
4,4'-DDD	0.24	2	1.22	20	7.81
4,4'-DDE	0.03	2.2	2.07	27	374
4,4'-DDT	0.02				
Aldrin	0.01				
Chlorpyrifos	0.1				
Cis-chlordane (alpha-chlordane)	0.08	0.5	2.26	6	4.79
Dieldrin	0.18	0.02	0.72	8	4.3
Endosulfan ether	0.1				
Endosulfan I	0.1				
Endosulfan II	0.1				
Endosulfan Lactone	0.1				
Endosulfan Sulfate	0.1				
Gamma-HCH (g-BHC, lindane)	0.08				
Heptachlor	0.04				
Heptachlor epoxide	0.1				
Hexachlorobenzene	0.06				
Mirex	0.16				
Total_DDT		1.58	3.89	46.1	51.7
Total_Pest					
Trans-nonachlor	0.09				

Ampelisca abdita and *Ampelisca* sp.). In these situations, species lists were modified to eliminate the possibility of duplication in species counts.

Standard ecological parameters of diversity (H' – calculated with log base 2), evenness ($J' = H'/H_{max}$, where H_{max}= ln (# of taxa in sample)), and richness (SR = S-1/lnN) were calculated for each station using the abundance of each species collected per grab.

Spatial Changes

The Bray-Curtis proportional similarity coefficient was used to conduct cluster analyses on faunal density data, with a flexible sorting strategy and a cluster intensity coefficient of ß= -0.25 (Bloom 1994). The groups generated through this procedure displayed relative similarity between zones based on species composition and density. Rare taxa were eliminated from analysis when running the cluster analysis. Only taxa that comprised 98% of all taxa collected were included in these analyses.

Temporal Changes

In an effort to separate the effects of historical disposal activities from natural annual variability when analyzing temporal changes in the benthic community structure, a subset of samples selected from the 1993 and 1994 studies was used to best represent typical, non-impacted samples from the area surrounding the disposal zone. Sampling in 1993-1994 was conducted over a two-year period to identify baseline conditions and annual variability in sediment characteristics and benthic infaunal assemblages. However, strata on the western edge of the disposal area (IG, IH, OG, OH) and within the disposal zone (DA, DB, DC, DD) had already been impacted by historical dumping at the time of the baseline study. Therefore, samples from these strata were excluded from temporal analyses. Sediments that have high silt/clay or $CaCO_3$ content are not representative of the benthic habitat typically found off the coast of South Carolina. Therefore, samples from 1993 and 1994 that had greater than the 90th percentile of silt/clay (3.617%) and greater than the 90th percentile of $CaCO_3$ (24.368%) were likely affected by historical dumping activities and were also excluded from analyses of temporal change.

To evaluate temporal change, analysis of variance (ANOVA) was performed to compare the benthic community in each strata processed in 2000 to the reference subset from 1993 and 1994. The benthic parameters evaluated included: density, number of species, density of general taxonomic groups (polychaetes, amphipods, molluscs, and 'other taxa'), and density of dominant taxa. When necessary, data were either $\log_{10}$ or rank transformed to meet assumptions of parametric analyses. ANOVAs were performed using Sigmastat for Windows version 2.03 (SPSS 1997).

RESULTS AND DISCUSSION

Sediment Characteristics

Spatial Comparisons

Detailed data on the sediment characteristics at each station are provided in Appendix 2. The majority of sediments collected in 2000 were composed of medium to fine-grained sands (mean = 78.0% sand content) mixed with moderate amounts of shell hash (mean = 17.4% $CaCO_3$). A contour map of sand content revealed that the sediments with the lowest percent sand content were primarily located within the disposal zone and in the northwestern outer boundary area (Figure 5). There was significantly less sand in disposal zone sediments than in inner or outer boundary zone sediments ($p < 0.001$), as would be expected following large-scale disposal of fine-grained inner harbor materials. There were few significant differences in sand content among strata; although strata OD, IA, and IF had significantly more sand than stratum DB ($p < 0.001$). A contour map of shell hash showed that $CaCO_3$ reached highest concentrations primarily along the eastern edge of the disposal zone (Figure 6). Shell hash was statistically less variable than sand content in the areas within and surrounding the disposal zone. There were no significant differences among zones or among strata with respect to shell hash content (Figure 7).

Silt/clay content in 2000 ranged from 0.1 to 67.8% with a mean of 4.6%. A contour map of silt/clay content revealed that muddy sediments were most common within the disposal zone as well as along the western boundary area (Figure 8). Disposal zone sediments had significantly more silt/clay than the inner or outer boundary zones (p

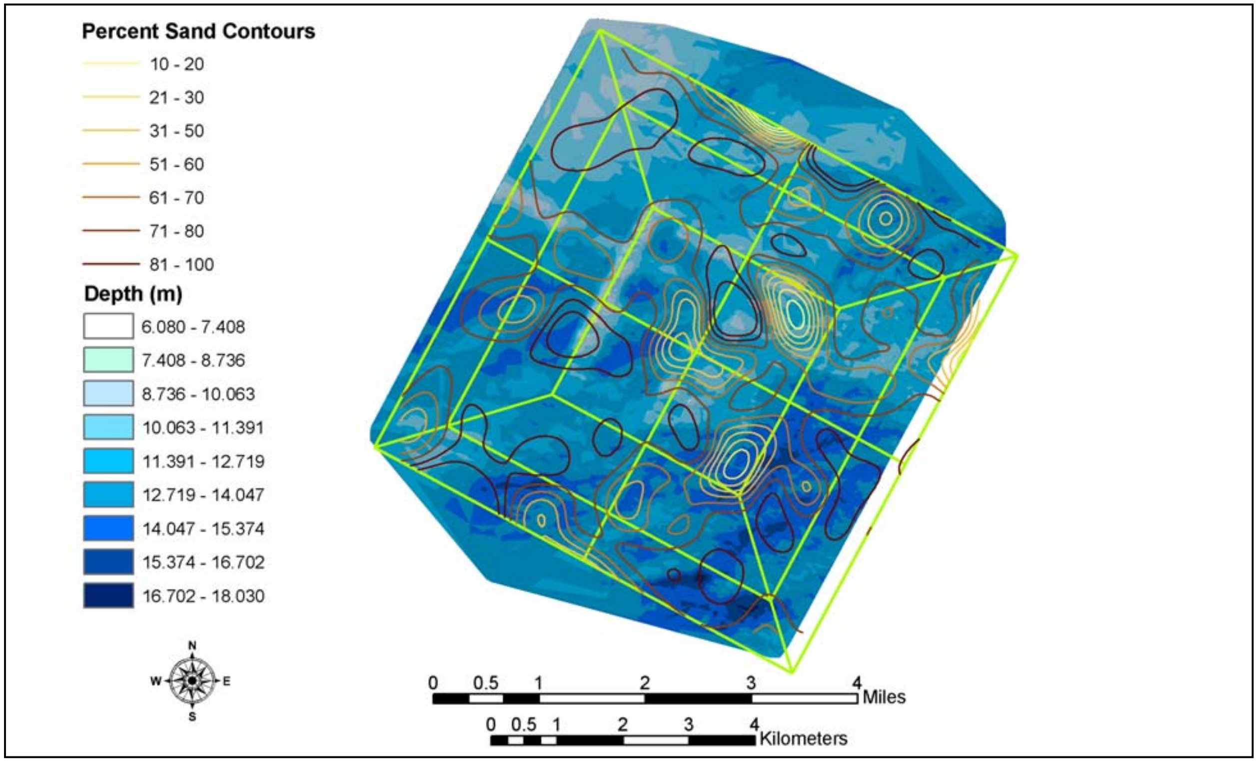


Figure 5. Contour map of the percentage of sand for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

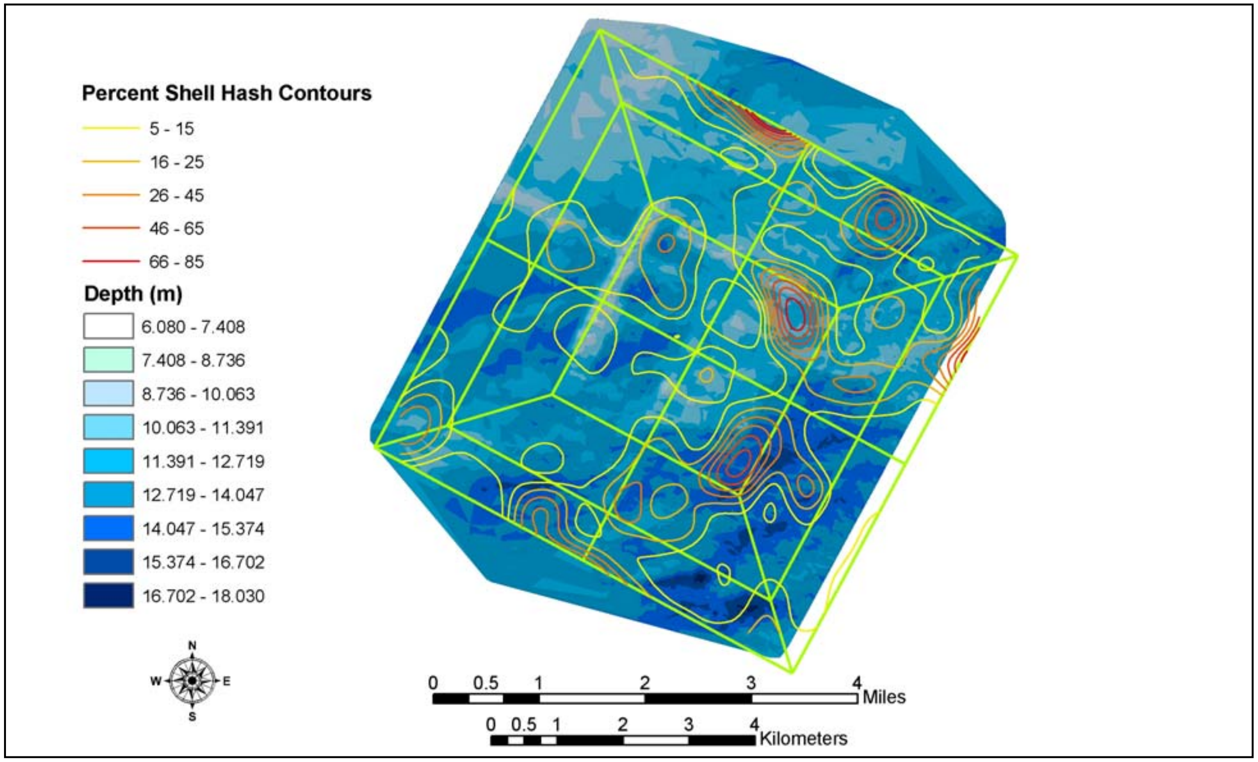


Figure 6. Contour map of the percentage of shell hash for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

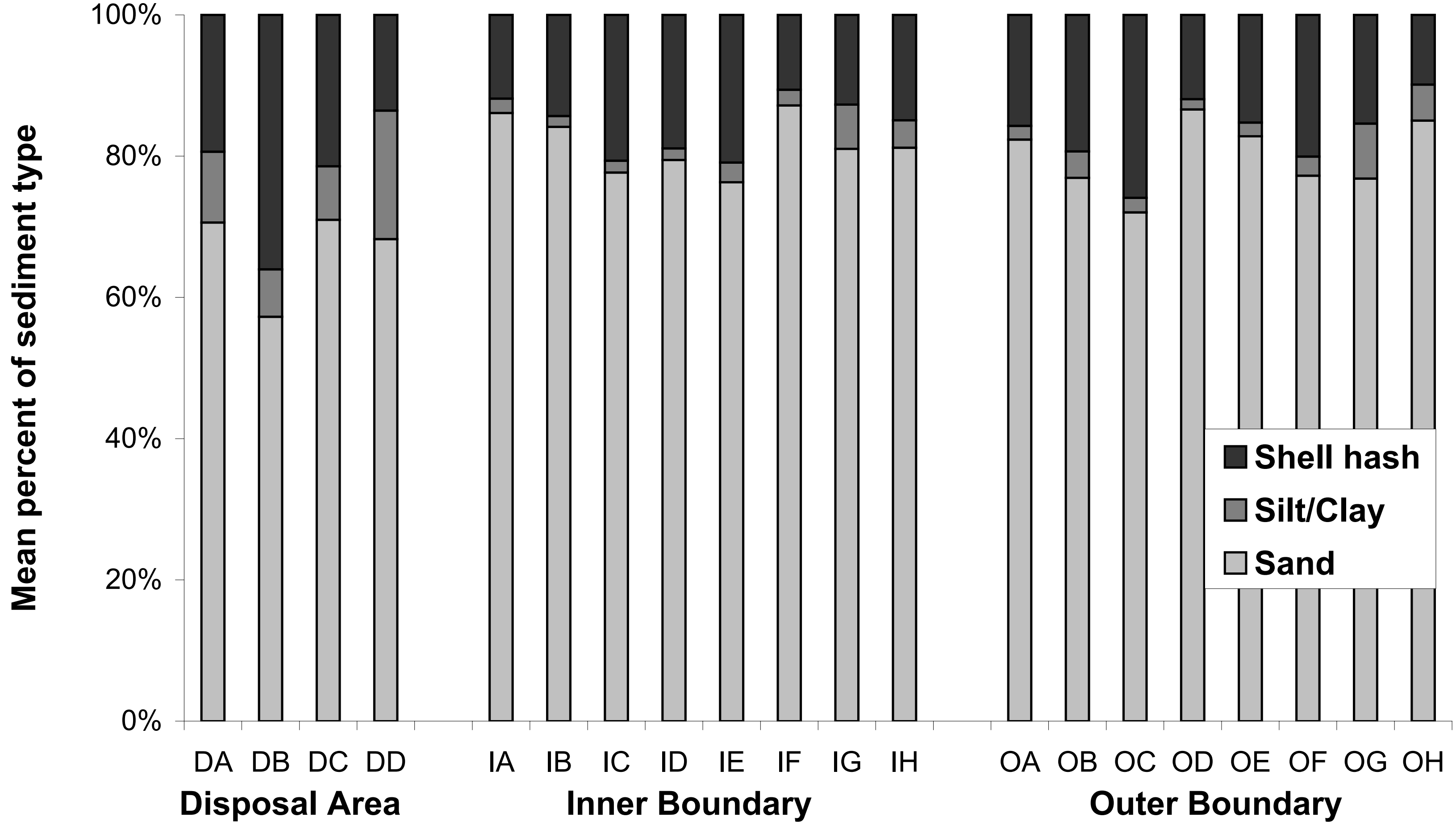


Figure 7. Sediment composition of strata. Data are based on the average of ten grab samples per stratum collected in 2000.

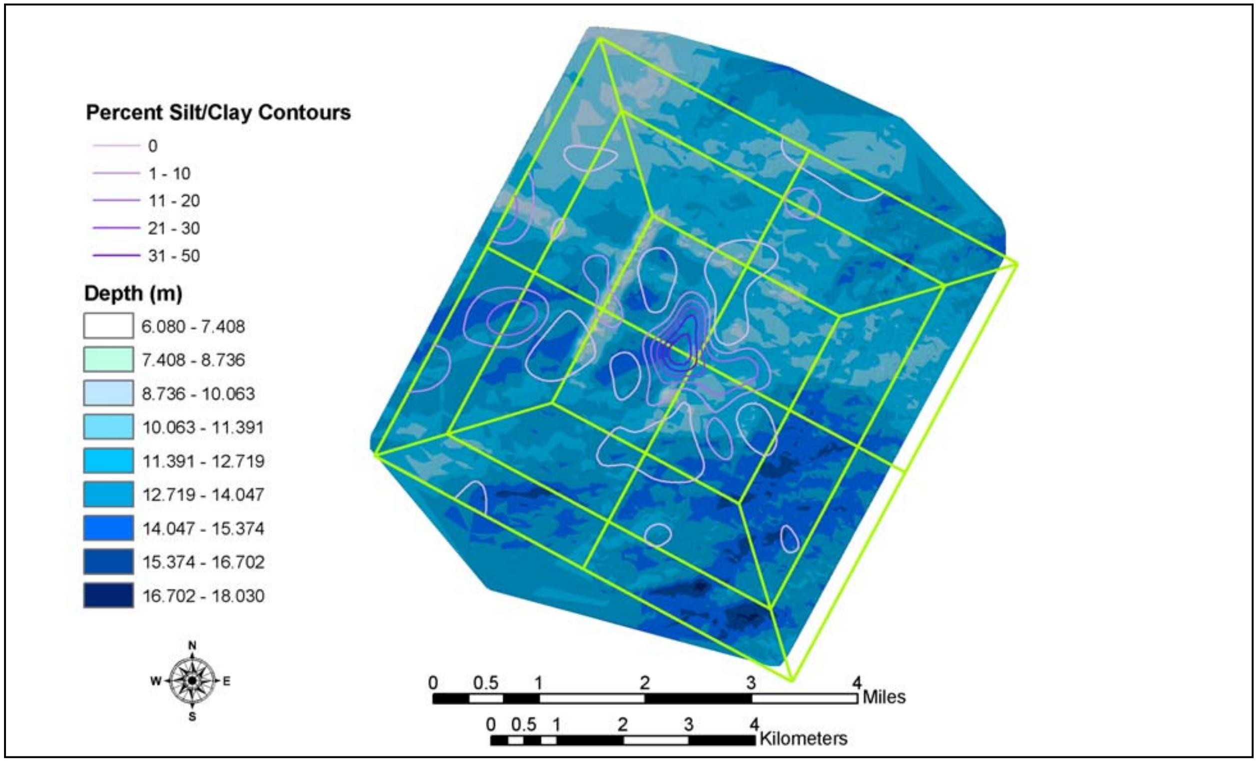


Figure 8. Contour map of the percentage of silt/clay for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

< 0.001) due to the placement of fine-grained inner harbor material in the area. Silt/clay content in strata OG, DD, DB, OB, and OH was significantly greater than a number of other strata, namely OD, IB, IC, IA, and OA ($p < 0.001$, Figure 7). In 2000, organic matter content in the vicinity of the disposal zone ranged from 0.62 to 8.67% with a mean of 1.09%. Disposal zone sediments had significantly more organic matter than both the inner and outer boundary zones (Figure 9). Numerous significant differences in organic matter content occurred among strata. In general, sediments on the western side and within the disposal zone (i.e. DA, DB, DC, OH, IH, OG, IG) had higher organic matter content than those on the eastern side (IC, OC, ID, OD).

Mean phi size of the sand content was 2.25 (range = 0.25 - 3.35). There were no significant differences in grain size among zones ($p = 0.121$) but differences did occur among strata ($p < 0.001$). Strata within the disposal zone (DA) and on the western side (OG, IG, OH, IH) had smaller grain size of the sand fraction than strata IE, OE, IC and OC which are located on the eastern and southern sides of the disposal area (Figure 10).

Temporal Comparisons

In general, sediments collected in 2000 had lower sand content and higher shell hash content than sediments in 1993 and 1994. The sand content in sediments collected in 2000 was significantly lower than sediments collected in 1993 and 1994 ($p < 0.001$), largely due to an increase in percent silt/clay content. The percentage of shell hash in 2000 sediments was significantly higher than values found for 1994 sediments ($p = 0.023$). Although no significant differences among zones occurred with respect to shell hash content, disposal zone sediments sampled in 2000 had greater shell hash content

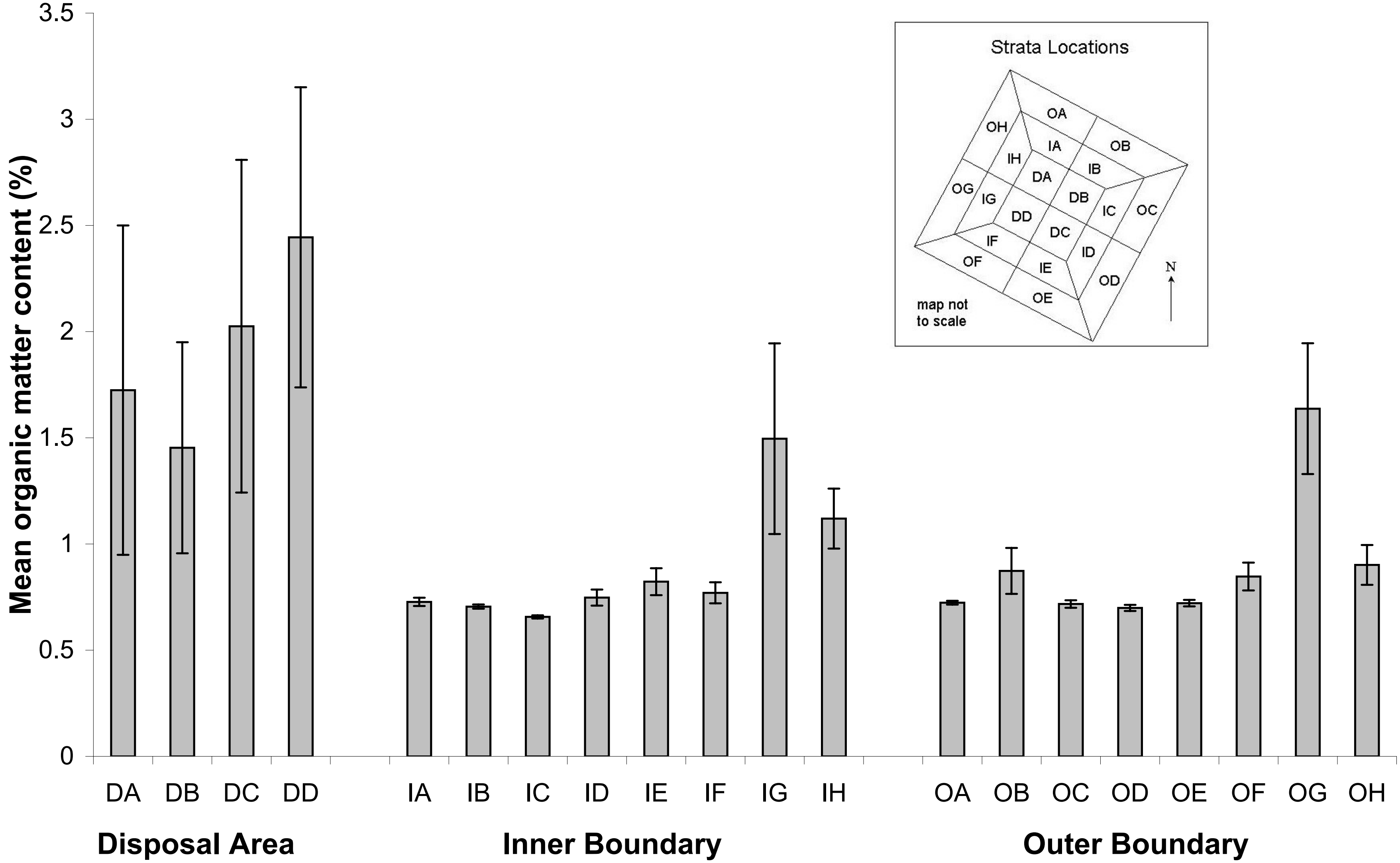


Figure 9. Mean organic matter content in each stratum sampled in 2000. Data are based on the average of ten grab samples per stratum collected in 2000. Error bars represent ±1standard error.

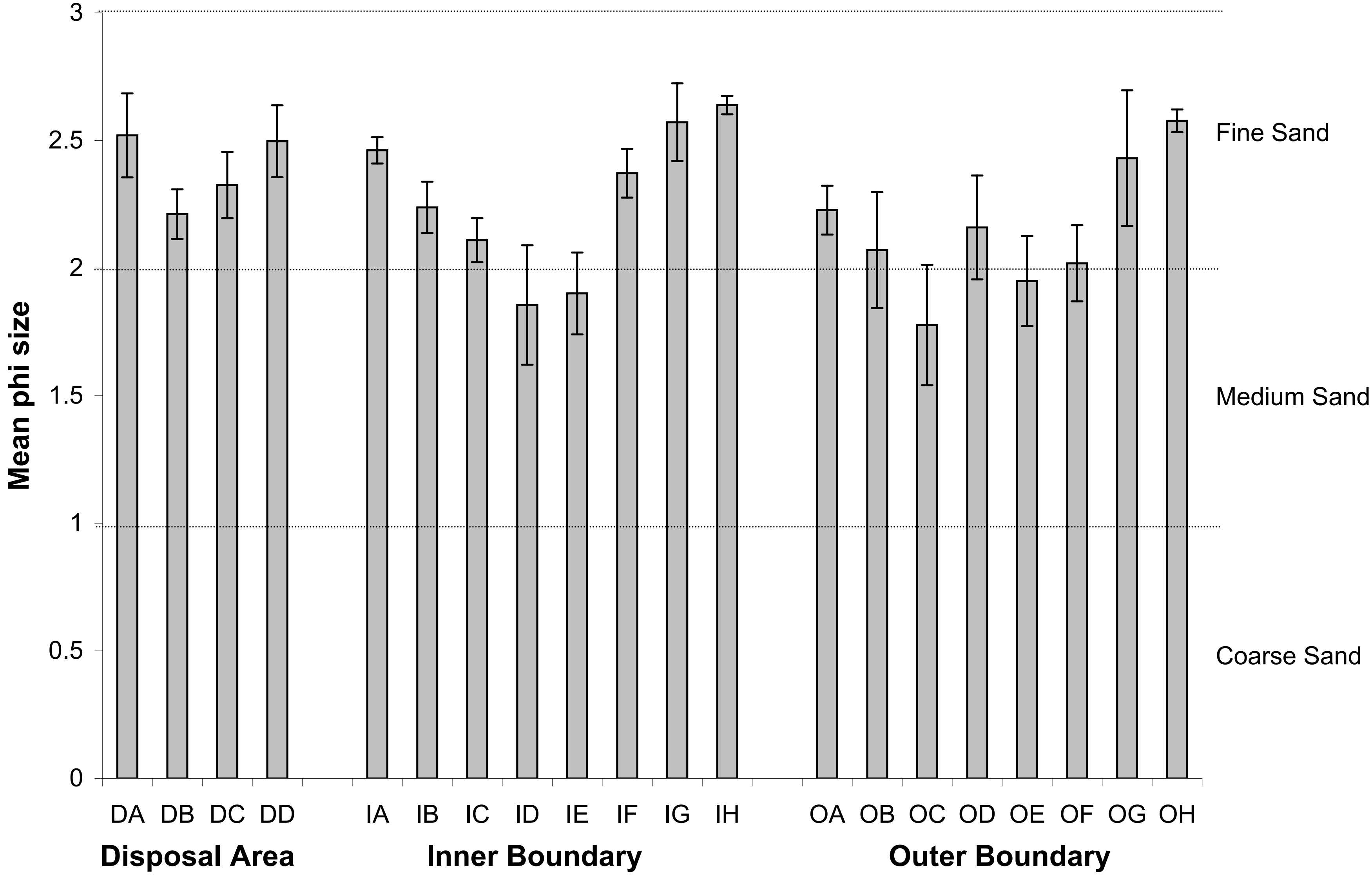


Figure 10. Mean grain size of sand for each stratum. Data are based on the average of ten grab samples per stratum collected in 2000. Error bars represent ±1 standard error.

than in 1994. Sediments dredged from the entrance channel were disposed on the eastern berm of the disposal area, and were generally high in shell hash content (USACE personal communication, Noakes 2001). Organic matter content and mean phi size showed no significant differences between the baseline 1993-1994 surveys and the 2000 survey ($p > 0.05$).

Overall, silt/clay content in 2000 was similar to 1993 values (mean = 4.60% in both years), but 2000 values were consistently higher than 1994 silt/clay content (mean = 2.15%). The difference observed in silt/clay content between 2000 and 1994 sediments was statistically significant for each of the three zones ($p < 0.001$, Figure 11). Van Dolah *et al*. (1997) reported that muddy sediments encountered in 1993 at the disposal area had dispersed by 1994 when only three stations, located in strata DC, DD, and OG, had greater than 10% silt/clay content. Fourteen stations sampled in 2000 had greater than 10% silt/clay content. These stations were located in each of the disposal area strata as well as in strata IG, OG, IB, and IH. Elevated silt/clay levels in the disposal zone were expected since millions of cubic yards of fine-grained materials were disposed at the site as part of the current Charleston Harbor Deepening Project. However, the elevated silt/clay content in strata outside the disposal zone, particularly to the west of the disposal zone, is likely a result of the movement of fines from the disposal zone, in addition to the material placed there as a result of unauthorized dumps.

Sampling efforts conducted by SCDNR in February-March 2000 as a response to unauthorized disposal activity (Jutte *et al.* 2001) documented a similar trend in increased silt/clay content, identifying a migration of fines in a predominately southwest direction from the disposal zone. Based on total gamma activity records from the 2000 sediment

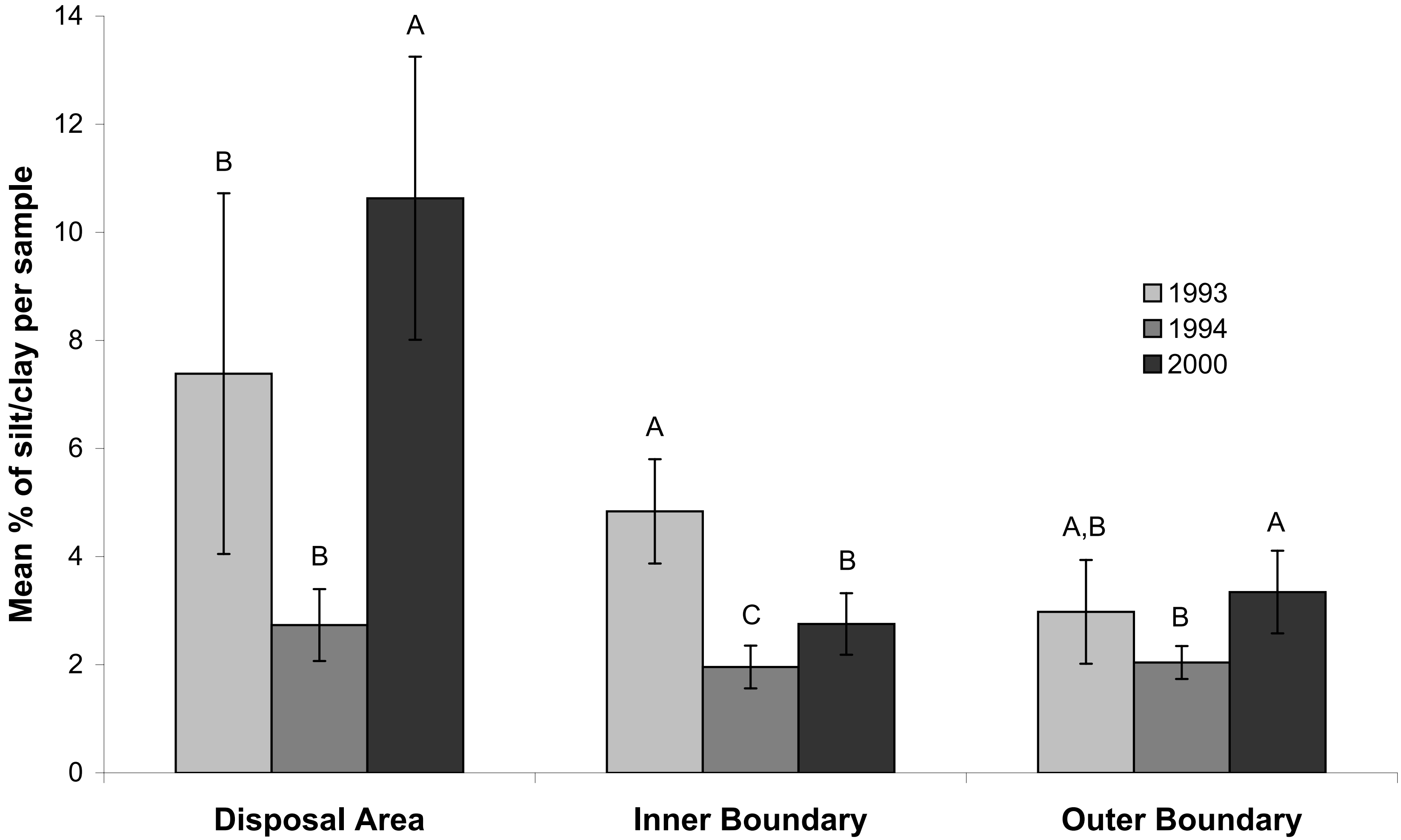


Figure 11. Mean percentage of silt/clay per sample in each zone. Differences between years were determined within each zone. Bars that do not share letters with each other are significantly different ($p < 0.05$). Error bars represent ± 1 standard error.

mapping survey, Noakes (2001) noted that the signature of disposal material on the western berm bulged in a westward direction (strata IH and IG) and also extended in a northwestern direction from the western berm (strata IA and IH). The western peak in gamma activity could be due in part to historical disposal activities or unauthorized disposal activity, while the northwestern peak in gamma activity appeared to be evidence of dredged material leaving barges as they entered or exited the disposal site. Noakes (2001) also mapped aluminum concentrations in the vicinity of the Charleston ODMDS. Aluminum is a good indicator of clay in surficial sediments, and high aluminum levels can be used to trace the dispersion of fine-grained sediments at the disposal site. Elevated aluminum levels were found within the disposal site, and also in strata OG and IA, reflecting dredged material from either recent or past disposal activities.

Sediment Contaminants

The concentrations of various trace metals detected in the samples collected during 2000 in the disposal zone and surrounding areas are summarized in Table 5. Trace metal concentrations were low throughout the entire study area, with all values below published bioeffects guidelines (Long *et al.* 1995, McDonald *et al.* 1996). In strata IA, IF, IE, IG, IH, OA, OB, OD, OE, OG, and OH, metal concentrations fell within the range of disposal zone concentrations for at least one metal. All the metals tested for in 2000 had their highest levels within the disposal zone except cadmium, which had highest concentrations in stratum OG. This is somewhat contradictory to the results from 1993 and 1994, when highest concentrations of metals were found in stratum IH, not the disposal zone. However, stratum IH had greater silt/clay content in 1993 and 1994 than in 2000. Contaminants often bind to fine-grained sediments (Olsen *et al.* 1982, Luoma 1989, Barrick and Prahl 1987) and it is not unexpected that strata with elevated silt/clay content would also have elevated sediment contaminants. Silt/clay content in 2000 was greatest in the disposal zone where inner harbor materials were placed, therefore, it stands to reason that contaminant concentrations would be highest in these strata.

The concentrations of various polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), and pesticides that were detected in samples collected during 2000 in the disposal zone and surrounding areas are summarized in Tables 6-8. These sediment contaminants were found in low concentrations throughout the study area, with no values exceeding published bioeffects levels (Long *et al*. 1995, McDonald *et al.* 1996). PAH concentrations above the detection limit were identified in strata DA, DB, DD, IG, and OG. These detected PAHs were chrysene+triphenylene, fluoranthene, perylene, and pyrene. PCB congeners 187, 29,44, 52, and 8 were found in concentrations above the detection limit in strata IA, IF, and OG. The pesticides chlorpyrifos, endosulfan ether, and endosulfan sulfate were found in concentrations above the detection limit in strata IA, IF, and OB.

Benthic Infaunal Assemblages

Overview—2000 Benthic Data

More than 15,700 organisms representing 402 taxa were collected from the 10 strata analyzed in 2000. A complete list of all taxa collected in these 10 strata is provided in Appendix 3, and a list of the dominant taxa collected is provided in Table 9. Mean density in these strata ranged from 1,415 to 9,323 individuals per m^2 with an average of

Table 5. Metal concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. None of the values exceeded published ERL or TEL levels. Values are expressed as parts per million except for aluminum and iron which are expressed as percent.

	Disposal Area				Inner Zone								Outer Zone							
Parameter	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
Aluminum	0.51	0.89	0.55	1.39	0.19	0.18	0.19	0.21	0.09	0.29	0.47	0.47	0.16	0.21	0.15	0.15	0.12	0.14	0.28	0.68
Arsenic	3.25	4.25	3.90	3.51	2.16	2.24	2.30	2.58	2.60	2.27	2.64	3.28	2.35	2.13	1.99	2.03	1.90	1.72	2.58	3.55
Cadmium	0.13	0.20	0.37	0.11	0.13	0.04	*	0.01	*	0.06	0.28	0.37	0.11	0.07	0.03	0.02	*	0.02	0.44	0.20
Chromium	6.70	14.90	24.60	12.10	2.35	1.52	1.23	1.71	*	2.50	6.04	7.15	4.11	2.99	*	*	*	*	4.72	7.08
Copper	0.81	0.37	1.61	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Iron	0.56	0.53	0.37	0.81	0.31	0.24	0.23	0.28	0.31	0.39	0.53	0.55	0.36	0.40	0.33	0.34	0.32	0.34	0.45	0.68
Lead	2.55	3.45	1.51	4.34	1.74	1.34	1.17	1.46	0.74	1.63	2.59	2.37	1.89	2.10	1.07	1.34	1.23	1.21	2.74	3.17
Manganese	57.40	90.50	42.00	80.10	53.90	37.50	31.30	35.40	21.60	51.95	53.40	67.80	50.90	38.80	25.70	30.80	23.20	33.50	62.10	68.80
Mercury	0.01	*	0.01	0.01	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0.01	*
Nickel	3.40	6.55	12.70	4.51	1.80	2.19	2.83	2.71	3.43	2.50	3.07	3.64	2.96	2.04	2.89	3.49	1.76	3.37	2.30	4.42
Selenium	*	0.31	1.08	*	*	*	*	*	0.05	*	*	*	*	0.13	*	*	0.21	*	0.06	0.11
Silver	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Zinc	12.30	11.30	11.80	13.80	*	*	*	*	*	5.60	9.98	7.17	*	*	*	*	*	3.48	4.92	*

* Metal was analyzed for but not detected

Table 6. PCBs detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

PCB	Disposal Area				Inner Zone								Outer Zone							
Congener	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
PCB 101	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 104	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 105	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 118	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 126	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 128	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 138	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 153	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 154	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 170	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 180	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 187	*	*	*	*	0.069	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 188	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 195	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 201	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 206	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 209	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 28	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 29	*	*	*	*	*	*	*	*	*	0.102	*	*	*	*	*	*	*	*	*	*
PCB 44	*	*	*	*	0.093	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 52	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0.069	*
PCB 66	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 77	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 8	*	*	*	*	0.366	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB 87	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total_PCB	*	*	*	*	0.529	*	*	*	*	0.102	*	*	*	*	*	*	*	*	0.069	*

* PCB was analyzed for but not detected

Table 7. Organic compounds detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

	Disposal Area				Inner Zone								Outer Zone							
Organic compound	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
1,6,7 Trimethylnaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1-Methylnaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1-Methylphenanthrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,6 Dimethylnaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Methylnaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Acenaphthene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Acenaphthylene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Anthracene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(a)anthracene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(a)pyrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(b)fluoranthene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(e)pyrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(g,h,i)perylene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzo(j+k)fluoranthene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Biphenyl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chrysene+Triphenylene	*	2.3	*	2.2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dibenz(a,h+a,c)anthracene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dibenzothiophene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fluoranthene	4.7	8.3	*	*	*	*	*	*	*	*	4.6	*	*	*	*	*	*	*	*	*
Fluorene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Indeno(1,2,3-cd)pyrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Naphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Perylene	36.0	11.5	*	24.5	*	*	*	*	*	*	6	*	*	*	*	*	*	*	6.1	*
Phenanthrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pyrene	4.7	6.0	*	*	*	*	*	*	*	*	3.6	*	*	*	*	*	*	*	3.3	*
Total_PAH	45.4	28.0	*	26.7	*	*	*	*	*	*	14.2	*	*	*	*	*	*	*	9.4	*

* PAH was analyzed for but not detected

Table 8. Pesticide concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

	Disposal Area				Inner Zone								Outer Zone							
Pesticide	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
2,4'-DDD	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4'-DDE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4'-DDT	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4,4'-DDD	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4,4'-DDE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4,4'-DDT	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aldrin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chlorpyrifos	*	*	*	*	0.59	*	*	*	*	0.15	*	*	*	0.10	*	*	*	*	*	*
Cis-chlordane (alpha-chlordane)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dieldrin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan ether	*	*	*	*	0.07	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan I	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan II	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan Lactone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan Sulfate	*	*	*	*	0.13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gamma-HCH (g-BHC, lindane)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor epoxide	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hexachlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mirex	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total_DDT	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total_Pest	*	*	*	*	0.79	*	*	*	*	0.15	*	*	*	0.10	*	*	*	*	*	*
Trans-nonachlor	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

* Pesticide was analyzed for but not detected

Table 9. The twenty-five numerically dominant taxa collected from the disposal zone and surrounding area in 2000. Values are mean number of organisms per m^2. P = Polychaete, A = Amphipod, M = Mollusc, O = Other.

			Non-Impacted Strata				Impacted Strata					
			Inner		Outer		Inner			Outer		
Species Name		Total	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Prionospio dayi	P	3078	128	338	148	453	350	415	465	105	353	325
Prionospio cristata	P	2413	83	750	773	88	30	23	85	80	480	23
Branchiostoma sp.	O	1840	323	605	450	238	28	30	10	120	28	10
Rhepoxynius epistomus	A	1818	175	78	318	438	180	83	185	143	43	178
Sabellaria vulgaris	P	1728	0	938	0	33	3	0	60	5	690	0
Nemertinea	O	1633	123	240	133	135	45	320	150	38	340	110
Prionospio sp.	P	1163	23	580	203	13	8	13	20	43	258	5
Sabellariidae	P	1103	0	1038	5	0	0	28	0	30	3	0
Magelona sp.	P	1018	8	13	8	5	23	333	38	13	523	58
Polygordiidae	O	1008	58	203	68	248	45	133	70	8	135	43
Mediomastus sp.	P	870	18	283	55	8	3	0	8	5	480	13
Eudevenopus honduranus	A	835	48	163	135	205	30	38	90	38	20	70
Protohaustorius deichmannae	A	800	73	35	65	75	75	50	168	83	10	168
Myriochele oculata	P	633	3	165	25	53	0	43	90	5	143	108
Bhawania heteroseta	P	578	3	98	13	0	0	0	0	3	463	0
Mediomastus californiensis	P	555	35	360	53	0	5	0	0	5	98	0
Mellita sp.	O	555	205	3	163	28	55	8	5	43	0	48
Goniada littorea	P	495	15	28	23	30	33	55	95	15	105	98
Ophiuroidea	O	493	20	25	243	50	3	45	13	5	75	15
Acanthohaustorius intermedius	A	455	68	25	53	63	90	25	10	90	0	33
Oligochaeta	O	453	30	125	75	93	13	20	5	3	70	20
Synelmis ewingi	P	435	0	0	0	0	0	0	0	10	425	0
Armandia maculata	P	380	38	105	85	18	10	20	35	20	40	10
Natica pusilla	M	370	28	50	48	30	23	58	60	18	40	18
Crassinella martinicensis	M	343	83	90	110	15	3	8	3	30	3	0
Percent of total abundance			66	71	61	68	69	68	70	69	66	72
Mean density per strata			2475	9323	5480	3505	1580	2975	2720	1415	7853	2063
Mean number of species			29	51	42	37	24	32	32	22	43	26
Mean H' - Diversity			4.01	4.19	4.22	4.27	3.85	3.96	4.21	3.88	4.12	3.98
Mean Evenness - J'			0.84	0.76	0.79	0.82	0.84	0.80	0.84	0.88	0.78	0.85
Mean Species Richness			6.21	9.03	7.75	7.40	5.65	6.47	6.67	5.36	7.68	5.71

3,939 individuals per m^2. The number of species per grab ranged from 22 to 51 species per grab with a mean of 34 species per grab. Diversity (H') ranged from 3.85 to 4.27 per strata with a mean of 4.07; mean diversity values for each strata are listed in Table 9.

Polychaetes were the most abundant taxonomic group, comprising 56% of all organisms identified in samples collected during 2000. Organisms falling in the category 'other taxa' (e.g. Nemertina, *Branchiostoma* sp., Polygordiidae) made up 21% of the total abundance. Amphipods and molluscs comprised 13% and 10% of the total abundance, respectively (Figure 12).

Fourteen taxa made up 50% of the total number of individuals. In decreasing order of abundance these taxa were *Prionospio dayi*, *Prionospio cristata, Branchiostoma* sp., *Rhepoxynius epistomus*, *Sabellaria vulgaris*, Nemertina, *Prionospio* sp., Sabellaridae, *Magelona* sp., Polygordiidae, *Mediomastus* sp., *Eudevenopus honduranus*, *Protohaustorius deichmannae*, and *Myriochele oculatus.* Although Sabellaridae and *Sabellaria vulgaris* were numerically dominant, the majority (> 85%) of these organisms were found in one (in the case of Sabellaridae) or two (in the case of *S. vulgaris*) samples. Therefore, these two taxa are not representative of the overall benthic community. If these two taxa are excluded, the remaining twelve numerically dominant taxa comprise 47% of the total abundance for 2000 data.

Spatial Changes—2000 Benthic Data

The benthic assemblages found in the strata that showed major changes in sediment composition (impacted) were somewhat different from those collected in areas with no evidence of change related to disposal activities (non-impacted). The eleven numerically dominant taxa in the non-impacted strata (IC, ID, OC, OD), in order of

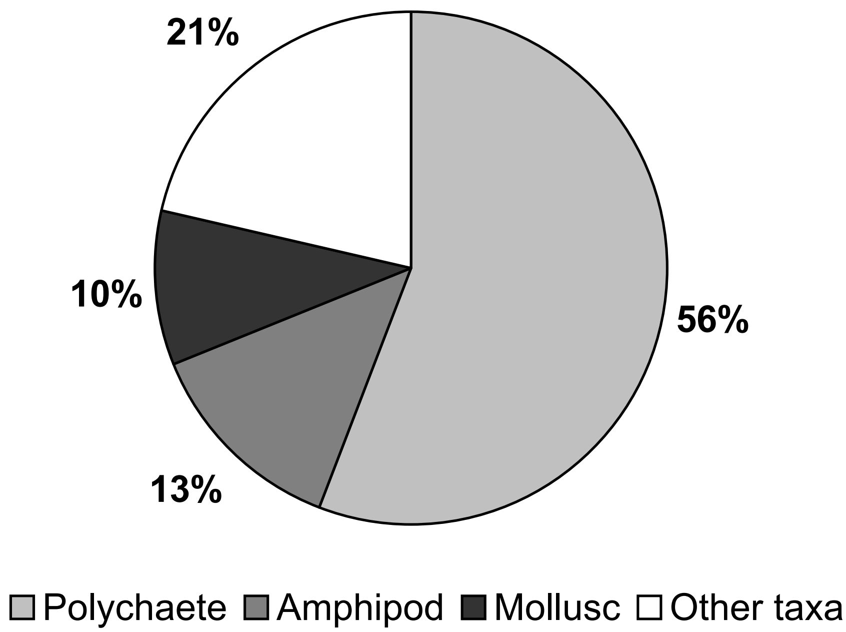


Figure 12. Percent abundance of general taxonomic groups from samples collected in 2000.

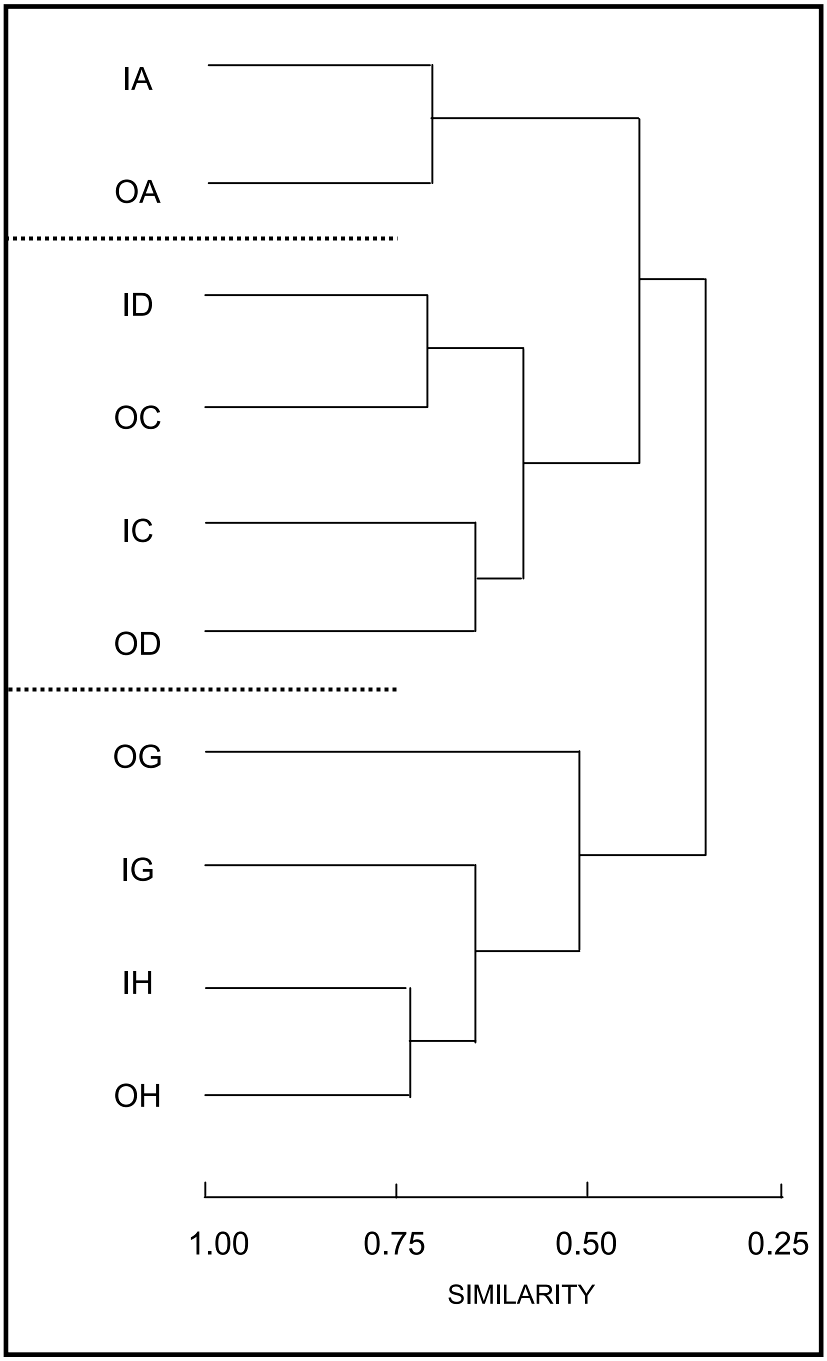
decreasing abundance, were: *Prionospio cristata*, *Branchiostoma* sp., *P. dayi*, Sabellaridae, *Rhepoxynius epistomus*, *Sabellaria vulgaris*, *Prionospio* sp., Nemertina, Polygordiidae, *Eudevenopus honduranus*, and *Mediomastus californiensis*. These taxa comprised 50% of the total abundance in the non-impacted strata. The eleven numerically dominant taxa in the impacted strata (IA, IG, IH, OA, OG, OH), in order of decreasing abundance, were: *P. dayi*, Nemertina, *Magelona* sp., *Rhepoxynuis epistomus*, *S. vulgaris*, *P. cristata*, *P. deichmannae*, *Mediomastus* sp., *Bhawania heteroseta*, *Synelmis ewingi*, and Polygordiidae. These taxa comprised 47% of the total abundance in the impacted strata.

Seven of these taxa were common between the impacted and non-impacted strata. However, a number of these common taxa were more abundant in one or the other of the two strata groups. For example, *P. cristata* and Polygordiidae were more abundant in non-impacted strata while *P. dayi* and Nemertina were more abundant in impacted strata. The taxa *Branchiostoma* sp. and *Eudevenopus honduranus* were among the top eleven taxa for the non-impacted strata but were not part of the dominant taxa list for the impacted strata. *Branchiostoma* sp. are rarely found in muddy sediments (Cory and Pierce 1967, Boschung and Gunter 1962). *Eudevenopus honduranus* is a sand-dwelling platyischnopid amphipod (Thomas and Barnard 1983, Cary 1996) that has been observed to exhibit declines in abundance following physical disruptions such as dredging activities (Jutte *et al*. 2001). Conversely, *Magelona* sp. and *Protohaustorius deichmannae* were dominant in the impacted strata but were not members of the eleven numerically dominant taxa in the non-impacted strata. The abundance of tentaculate feeding polychaetes, such as *Magelona* sp., were found to be positively correlated with silt/clay content and organic matter content following dredging activities in Myrtle Beach (Jutte *et al.* 1999). These findings suggest patterns in animal-sediment relationships that may be indicative of non-impacted versus impacted strata.

To further evaluate spatial differences in the benthic community inhabiting the disposal zone and surrounding areas, a cluster analysis of the data was conducted. Cluster analysis grouped the strata analyzed in 2000 based on the composition and density of the benthic infaunal community (Figure 13). The density and composition of the benthos in strata OG, IG, IH, and OH (impacted areas) were most similar to one another. Strata in the boundary areas to the east of the disposal zone in IC, OC, ID, and OD (non-impacted areas) formed a second distinct cluster. The third data cluster was composed of strata IA and OA, which are located to the northwest of the disposal area and are subjected to dredge trailings based on side scan sonar surveys (Gayes *et al.* 2002) and sediment mapping data (Noakes 2001). These findings suggest that the western, eastern, and northwestern boundary strata support distinct faunal assemblages. The higher level of similarity between the northwestern and eastern strata suggests that the northwestern strata have been less impacted by disposal activities than the western strata. This could be due to the identification and correction of the trailing problem following the 2000 side scan survey, while ongoing migration of disposal material continues to impact the western strata.

Temporal Changes

To evaluate temporal changes in the benthic communities, data from 1993 and 1994 were divided into those stations within strata IA, IB, IC, ID, IE, IF, OA, OB, OC,



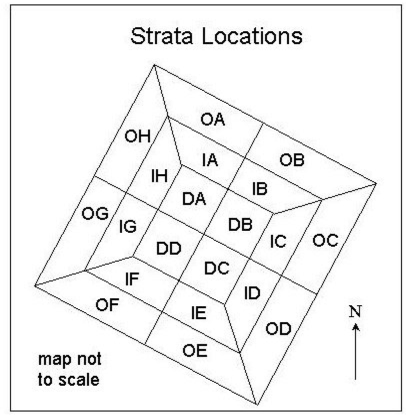


Figure 13. Results of normal cluster analysis using Bray-Curtis similarity coefficient on benthic data collected in 2000.

OD, OE, and OF that also had less than the 90th percentile silt/clay and the 90th percentile $CaCO_3$. This subset of reference data was then used for comparison to the 2000 data.

Analyses of benthic community metrics between the three years revealed significant effects of disposal activities on both mean density and number of species. Mean density was significantly lower in 2000 than in 1993 or 1994 in four of the six impacted strata while there were no significant differences between mean density in 2000 and the earlier years in three of the four non-impacted strata (Figure 14). The number of species was significantly lower in 2000 than in 1993 or 1994 at five of the six impacted strata, while three of the four non-impacted strata had no significant differences among years (Figure 15). These effects on the number of species and the density of benthic organisms were apparent in both the areas adjacent to the disposal zone (i.e. inner zone) as well as in the areas farther away from the disposal zone (i.e. outer zone). The non-impacted stratum IC had significantly lower faunal density and number of species in 2000 than in 1993 or 1994, although the cause of these trends is unclear. A number of benthic organisms, including the amphipod *Bathyporeia parkeri*, the pelecypod *Parvilucina multilineata*, and the archiannelid Polygordiidae had significantly higher densities in the 1993-1994 references stations than in stratum IC in 2000.

The general taxonomic composition in the boundary zones were altered following disposal activities, however, most of these differences cannot be attributed to the disposal of dredge material. Densities of the most abundant taxonomic groups, the polychaetes, showed no discernible pattern related to disposal activities. The density of molluscs was significantly lower in 2000 than in 1993 or 1994 in nine of the strata (all the impacted strata and three of four non-impacted strata). Also, the density of amphipods was

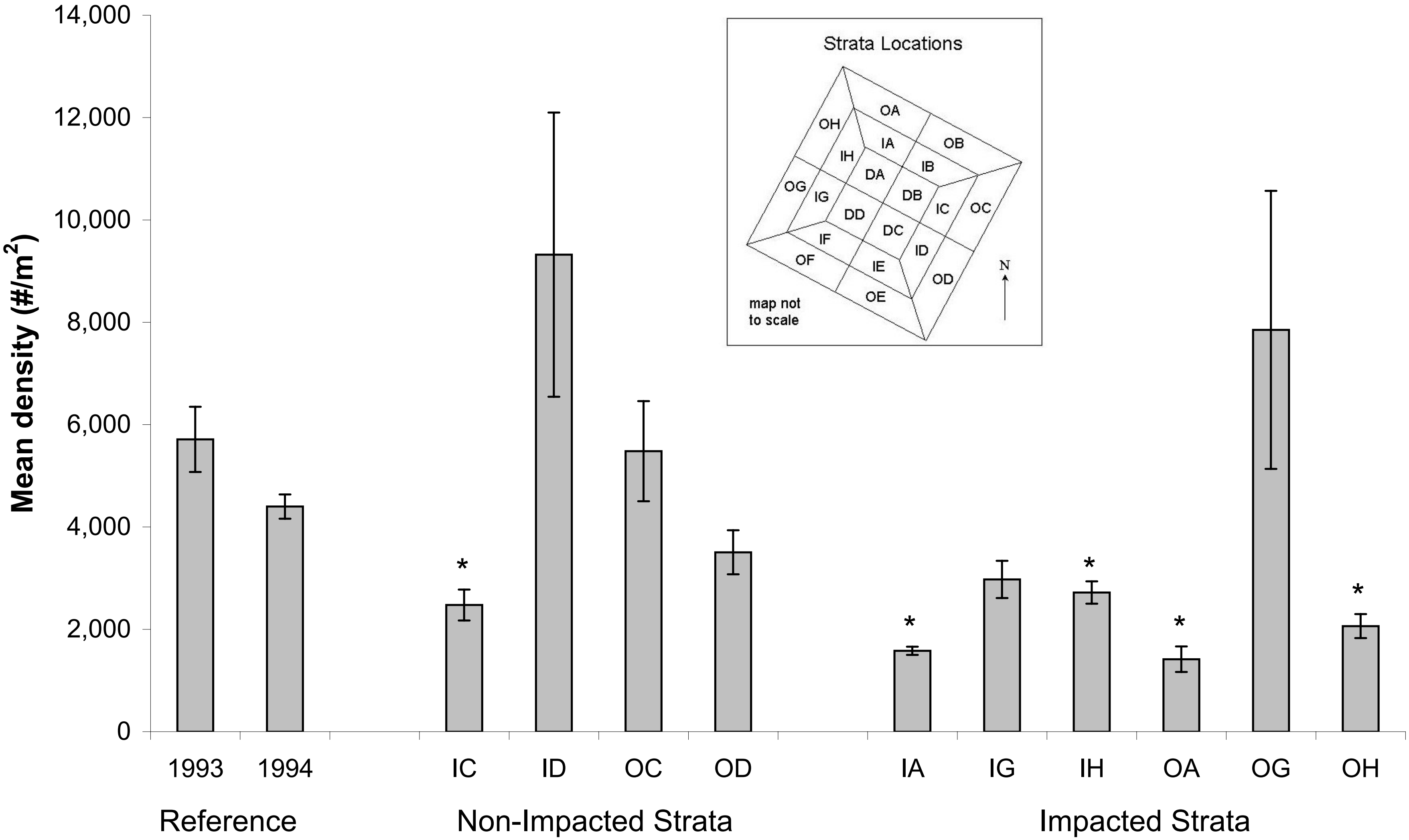


Figure 14. Mean density at 1993/1994 reference stations and strata from 2000. Error bars represent +1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at p <0.05).

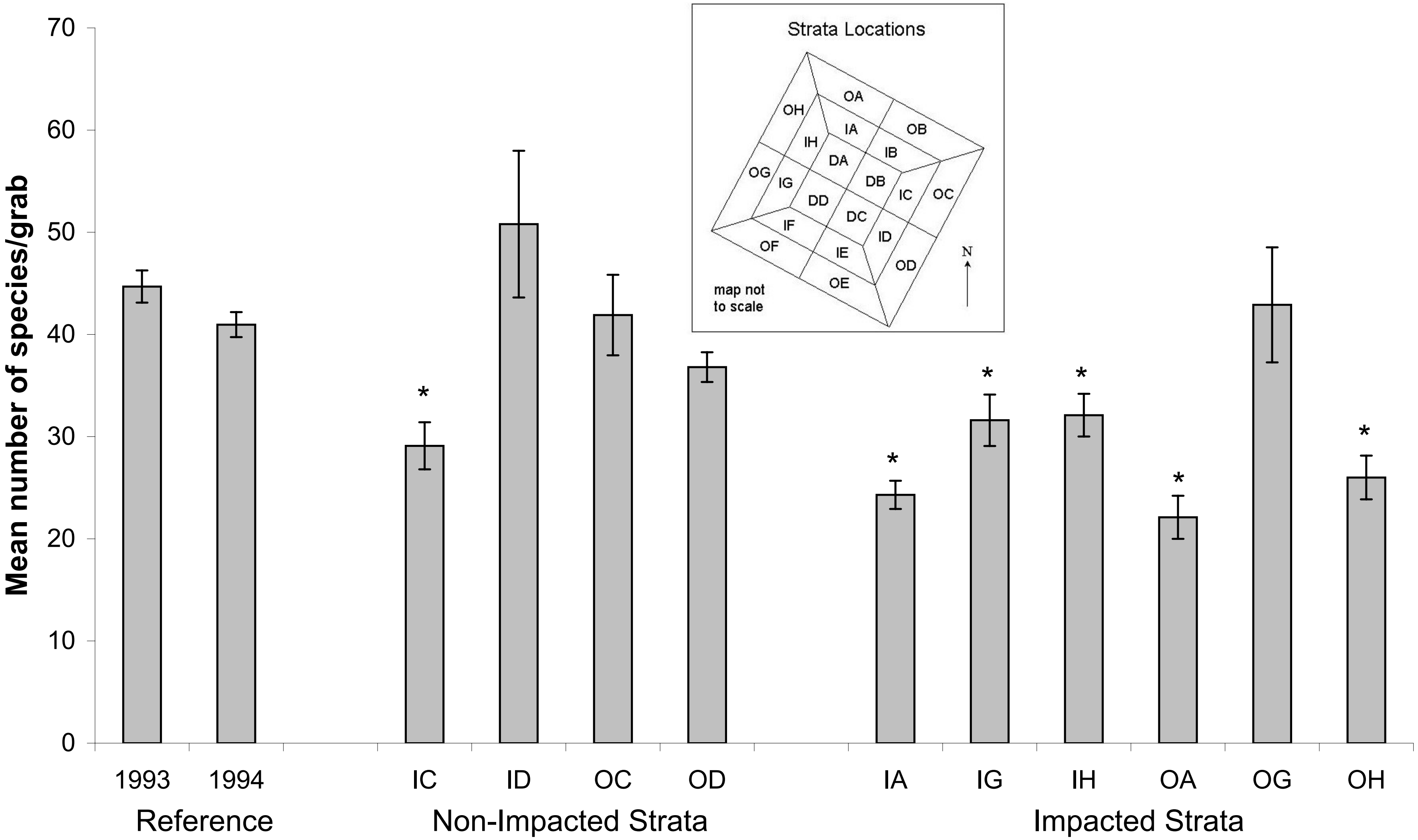


Figure 15. Number of species at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at p <0.05).

significantly lower in 2000 than in 1993 and 1994 in seven of the strata (five of six impacted strata and two of four non-impacted strata). Because differences between the baseline assessment and the 2000 assessment were encountered in both the impacted and non-impacted strata with respect to mollusc and amphipod densities, these effects appear to be related to year-to-year variability and not to disposal activities. However, the density of organisms in the 'other taxa' category does appear to have been altered by disposal activities. Organisms in the 'other taxa' category had significantly lower densities in 2000 than in 1993 or 1994 in four of the six impacted strata, whereas none of the non-impacted strata had significant differences among years (Figure 16).

An overall species list for the 1993, 1994, and 2000 surveys included the following top ten dominant taxa: the polychaetes *Prionospio cristata* and *Prionospio dayi*; the amphipods *Rhepoxynius epistomus* and *Bathyporeia parkeri*; the molluscs *Parvilucina multilineata, Crassinella martinicensis* and *Tellina* sp.; and Nemertina, *Branchiostoma* sp. and Polygordiidae in the 'other taxa' category. To examine impacts of disposal activities on these taxa, ANOVAs were performed to compare the 2000 data by strata to the reference samples from 1993 and 1994. Eight of the ten dominant taxa had no discernible differences in faunal densities among the three years. The density of two taxa, *Prionospio dayi* and *Crassinella martinicensis*, appeared to be significantly altered by changes related to disposal activities.

In five of the six impacted strata, *P. dayi* had significantly higher densities in 2000 than in 1993 or 1994, while three of the four non-impacted strata had no significant differences in *P. dayi* density among years (Figure 17). *P. dayi* is a spionid polychaete classified as both a deposit feeder and a suspension feeder (Fauchald and Jumars 1979,

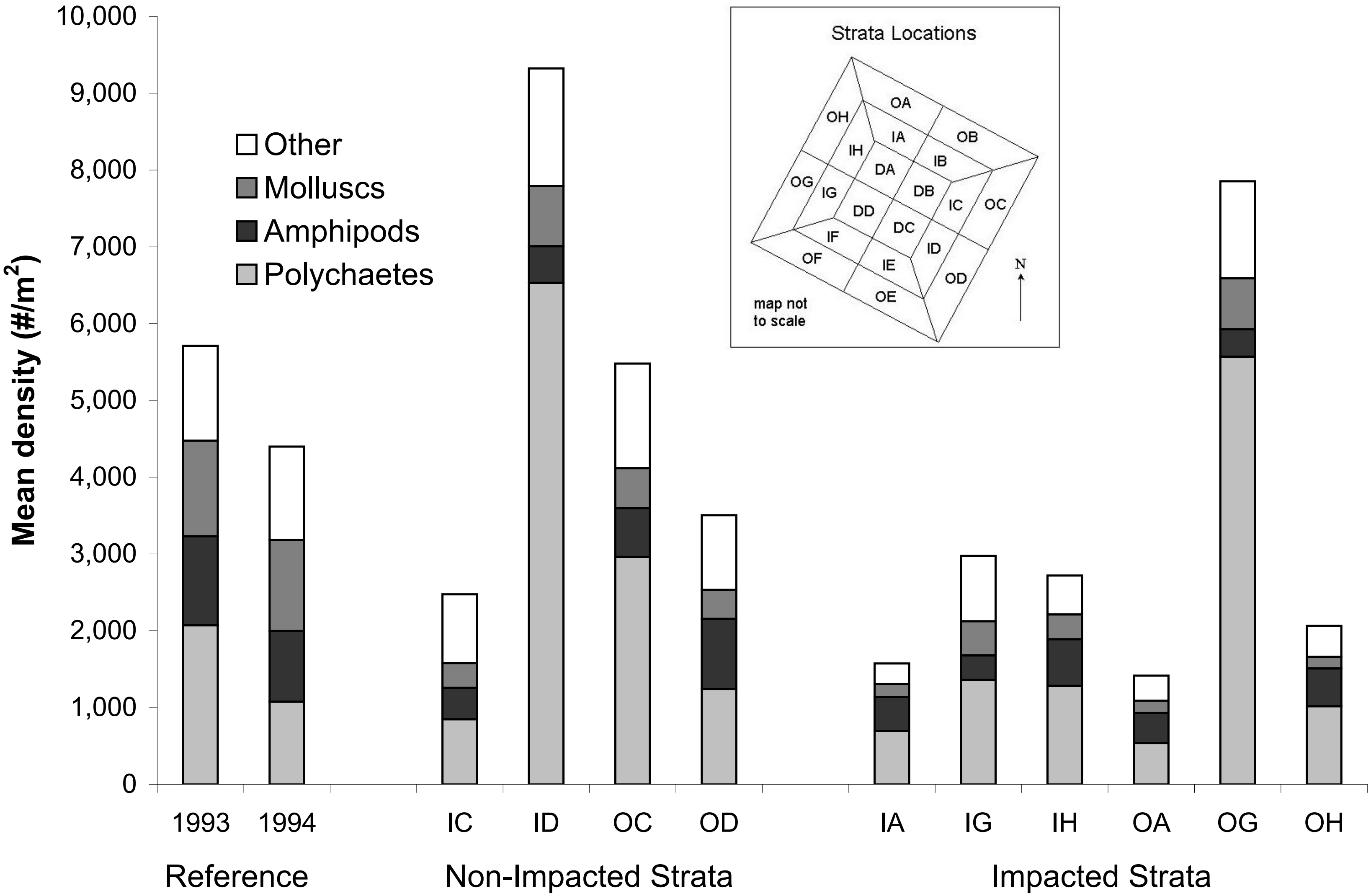


Figure 16. Mean density of general taxonomic groups at 1993/1994 reference stations and strata from 2000.

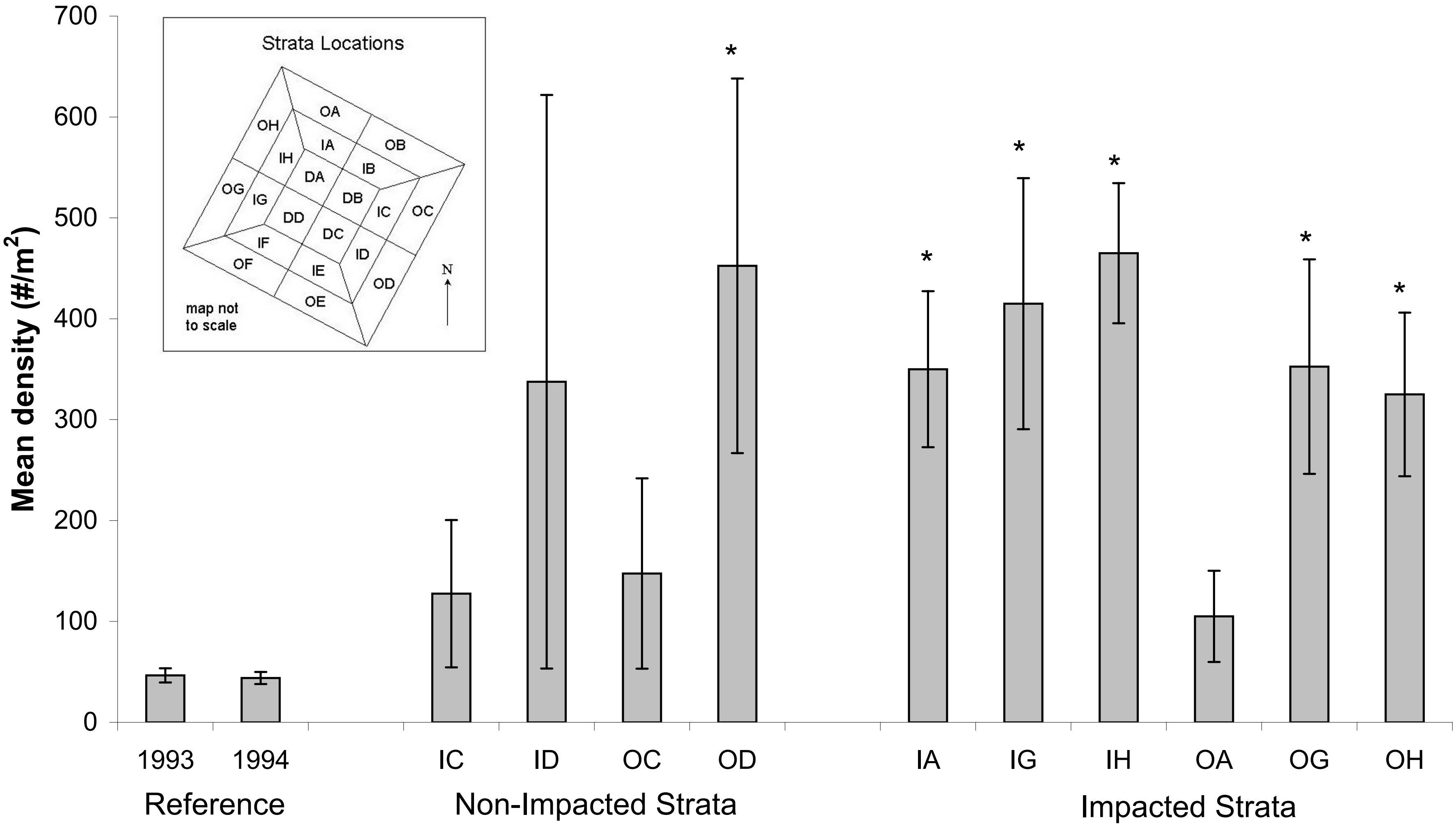


Figure 17. Mean density of *P. dayi* at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 > 1993 and 1994 (significant difference at $p < 0.05$).

Dauer *et al.* 1981), depending on the availability of suspended and deposited particles. Large abundances of this species might be expected with increased levels of surficial sediments with relatively high organic matter content or with deposition of sediments high in organic matter composition. Spionid polychaetes, when filter-feeding, depend on particles making direct contact with their elongate, flexible feeding palps ('impingement-feeders', Steele-Petrovic 1975). This feeding technique, which captures larger size particles and allows smaller particles to pass through, makes these organisms tolerant of high turbidity water conditions. This is not the case for filter-feeding bivalves, which filter water through an organ that traps all particles larger than a certain size (see below), and becomes clogged in turbid waters (Dauer *et al.* 1981).

C. martinicensis had significantly lower densities in 2000 than in 1993 or 1994 in all of the impacted strata, but three of the four non-impacted strata had no significant differences among years (Figure 18). This mollusc is commonly found in shelly or sandy sediments (Harry 1966) and the presence of disposal materials in the impacted strata may have reduced the abundance of this species. Suspension-feeding bivalves such as *C. martinicensis* can suffer disorders caused by the abrasive action of silt/clay, the exposure of toxicants absorbed to the fine materials (Blake *et al.* 1996), or the clogging of gills (Dauer *et al.* 1981). While the responses to these physical conditions are often sublethal, the severity of the response depends on the species, life stage, time of year, duration of exposure, and natural habitat of the species. Clarke and Miller-Way (1992) found that molluscs were absent from disposal-affected areas in Mobile Bay, Alabama. Future assessments of biological impacts from disposal activities at the Charleston disposal area may further elucidate relationships between alterations in sediment composition and certain feeding types (e.g suspension/filter feeders).

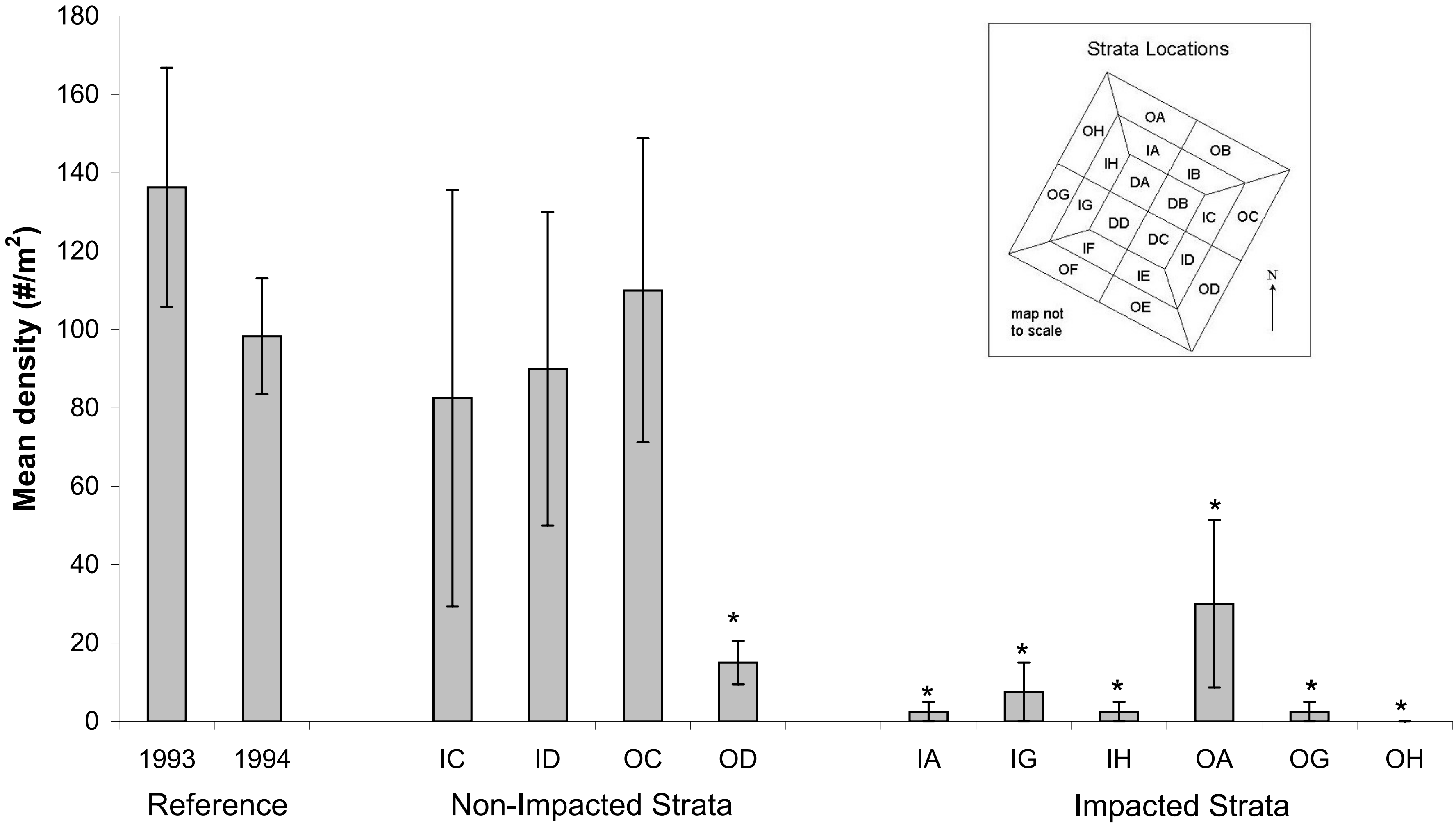


Figure 18. Mean density of *C. martinicensis* at 1993/1994 reference stations and strata from 2000. Error bars represent $\pm$1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at $p < 0.05$).

CONCLUSIONS AND RECOMMENDATIONS

The disposal of fine-grained inner harbor sediments into the Charleston offshore disposal zone has resulted in a number of physical and biological impacts to the area surrounding the disposal zone. Silt/clay and organic matter content to the west of the disposal zone are elevated above typical levels in nearshore South Carolina waters. These changes in sediment characteristics have, in turn, impacted the benthic community living to the west of the disposal zone.

Disposal operations placed fine-grained inner harbor materials in the western and central portions of the disposal zone, and shelly sands from the entrance channel on the eastern berm of the disposal zone. Some unauthorized dumping also occurred in areas to the west and south (mostly within the inner boundary zone) of the disposal zone. As expected, sediment characteristics within the disposal zone were significantly different from earlier baseline sampling in 1993 and 1994. These effects were intended to be limited to the disposal zone, however, the significantly increased levels of silt/clay in the inner and outer boundary zones in 2000 when compared to baseline levels clearly show the effects were more pervasive. The likely source of the elevated silt/clay levels in the boundary zones is material migrating from the disposal site or unauthorized dumps.

The benthic community structure in the boundary areas impacted by disposal activities showed decreased faunal densities and number of species. In addition, effects were observed in particular taxonomic groups and several dominant species. The condition of the benthic infaunal assemblages in the boundary zones was the focus of this report; while biological effects within the disposal zone were obviously anticipated, analyses in these areas was limited to sediment characteristics and sediment contaminants in an effort to lower study costs. Declines in the densities of organisms in the boundary zones and disposal zone may cause longer-term effects due to reduced local recruitment.

Based on these findings, SCDNR recommends that the planned post-assessment and three-year post-assessment of the Charleston ODMDS and surrounding areas be completed using the same sampling strategies used for the baseline and 2000 surveys. In addition, the continuation of monitoring efforts at hard bottom reef sites, planned through at least spring 2005, is warranted to document status of biological resources, habitat condition, and areal extent.

Monitoring activities should not cease upon the completion of large-scale disposal operations because these monitoring efforts are needed to document the duration and fate of disposed sediments and long-term trends at the site. Continued monitoring of the site is particularly critical in the face of ongoing disposal operations, future disposal operations, and possible site expansion requests. Based on the data collected during the post-assessment studies, specific recommendations for monitoring in subsequent years of the program may change, and findings may warrant an extension in the length of the monitoring program.

SUMMARY

- Disposal operations have occurred in the general vicinity of the Charleston Ocean Dredged Material Disposal Site (ODMDS) since 1896. The area currently permitted for disposal activities is a four square mile disposal zone approved by an interagency team in 1993.
- Extensive monitoring efforts to assess sediment characteristics, sediment contaminants, water current and wave conditions, and benthic assemblages have been conducted in the area, in addition to side scan sonar surveys, and sediment mapping surveys.
- In anticipation of the 1999-2002 Charleston Harbor deepening project, baseline monitoring activities at the disposal zone and surrounding areas (inner and outer boundary zones) took place in 1993 and 1994. These studies were conducted to better understand natural variability in sediment characteristics and benthic infaunal assemblages in the area. The effects of historical dumping activities in the area were acknowledged.
- Unauthorized disposal activities occurred in 1999 and 2000 as part of the 1999-2002 Charleston Harbor deepening project. Sediments high in silt/clay content were found in areas surrounding the disposal zone, likely due to the movement of fines from the disposal site, combined with the disposal of fine-grained materials from unauthorized dumps.
- This report provides an interim assessment of the sediment characteristics, sediment contaminants, and benthic infaunal assemblages in the disposal area and surrounding boundary areas. These efforts, in addition to sediment mapping

surveys, side scan sonar surveys, hard bottom reef assessments, and measurements of disposal material mobility and transport were planned to occur approximately halfway through the 1999-2002 Charleston Harbor deepening project.

- Benthic grab samples were collected at 200 sites within the disposal zone, inner boundary zone, and outer boundary zone using a GPS positioning system and were selected from the original random array of 400 stations sampled in 1993-1994. Each grab sample was sub-sampled for analysis of sediment characteristics and sediment contaminants. The remainder of the grab sample was sieved to remove benthic organisms for identification in the laboratory. Sediment and benthic infaunal samples were processed by SCDNR, and contaminant samples were processed by NOAA-NOS-CCEHBR. Benthic sample processing followed a tiered approach with a subset of 10 of the total 20 strata being analyzed. Strata were classified as impacted or non-impacted based on findings from the sediment mapping survey (Noakes 2001), side scan sonar survey (Gayes 2001), and sediment analyses.
- The majority of sediments collected in 2000 were composed of medium to fine-grained sands mixed with moderate amounts of shell hash. Due to the extensive dumping of fine-grained inner harbor material in the disposal site, there was significantly higher silt/clay content and organic matter content and significantly lower sand content in the disposal zone than in the inner and outer boundary areas. There were no significant differences among zones with respect to shell hash ($CaCO_3$) content or the mean grain size of sand.

- Silt/clay content was significantly higher in the disposal zone, inner boundary, and outer boundary zones in 2000 than in 1994. The most impacted areas were the disposal zone and strata IG, IH, OG, and IB, likely due to migration of material from the disposal site and unauthorized disposal material. Temporal comparisons of other sediment characteristics indicated that sand content was significantly lower in the disposal zone in 2000 than in baseline surveys, and shell hash content in the disposal zone was significantly higher in 2000 than in 1994.
- Sediment contaminant levels were low in all strata sampled in 2000. All trace metal, polyaromatic hydrocarbon (PAH), polychlorinated biphenyl (PCB), and pesticide concentrations were below published bioeffects levels.
- Over 15,700 organisms representing 402 taxa were identified in the 10 strata analyzed in 2000. The average number of species per grab was 34, with an overall mean diversity (H') of 4.07. Polychaetes were the most dominant taxonomic group (56%), followed by organisms in the 'other taxa' category (21%), amphipods (13%), and molluscs (10%).
- There was some overlap in the dominant benthic organisms found in the impacted and non-impacted strata. Several species exhibited higher dominance at either the impacted or the non-impacted sites; the patterns in the density of these species was most likely due to differences in sediment characteristics.
- A cluster analysis of the 2000 data resulted in three groupings based on the density and composition of organisms: the western boundary strata, the eastern boundary strata, and the northwestern boundary strata. The faunal assemblage in the northwestern strata was more similar to the eastern strata than the western

strata. This suggests that the measures taken to eliminate dredge trailings over the northwestern region in 2000 may have minimized benthic impacts or allowed for greater faunal recovery, while ongoing migration of disposal material continues to impact the western strata.

- Temporal analyses of benthic community structure compared 2000 data to a subset of 1993-1994 data. The subset selected best typified natural, baseline conditions, and eliminated from analysis samples collected in 1993-1994 that may have been influenced by historical disposal activities.
- Mean faunal density and the mean number of species were significantly lower in 2000 than 1993 or 1994 in the majority of impacted strata, while most non-impacted strata showed no significant differences between years. General taxonomic structure was also affected by disposal activities. Organisms in the 'other taxa' category had significant declines in the majority of impacted strata in 2000, but no difference among years was observed in non-impacted strata. The consistent declines in amphipods and molluscs in all strata in 2000 are most likely due to annual variability.
- Two dominant organisms, the polychaete *Prionospio dayi* and the bivalve *Crassinella martinicensis*, showed significant shifts in faunal densities that appeared to be associated with disposal operations. Increased silt/clay content in surficial sediments may be beneficial to *P. dayi*, due to its feeding mode, while fine sediments may lead to sublethal effects or mortality in *C. martinicensis*.
- Based on these findings, SCDNR recommends that the planned post-assessment and three-year post-assessment of the disposal zone and surrounding boundary

areas be completed using the same sampling strategies used for the baseline and 2000 surveys. Continued monitoring of hard bottom reef sites is also warranted. These monitoring efforts are needed to document the duration and fate of disposed sediment and long-term trends at the site.

ACKNOWLEDGEMENTS

The authors thank the many SCDNR staff who assisted with sample collection and laboratory processing for this project: Marty Levisen, Leona Forbes, Lisa McLean, George Riekerk, Stacie Crowe, Steve Burns, John Jones, Mike Schwarz, Jeff Jacobs, and William Merritt. Special thanks also go to Mary Ellen Williams and Christine Martinelli for their administrative support.

We also wish to thank Robin Coller-Socha, Lincoln Blake, and Kevin Widner at the U.S. Army Corps of Engineers, Charleston District for their assistance throughout the project. The U.S. Army Corps of Engineers funded these monitoring efforts through Cooperative Agreement SAC0007.

LITERATURE CITED

Barrick, R.C. and P.G. Prahl. 1987. Hydrocarbon geochemistry of the Puget Sound regions-III. Polycyclic aromatic hydrocarbons in sediments. Estuarine, Coastal, and Shelf Science. 25:175-191.

Blake, N.J., L.J. Doyle, and J.J. Culter. 1996. Impacts and direct effects of sand dredging for beach renourishment on the benthic organisms and geology of the west Florida shelf. Final report prepared by the Florida Institute of Oceanography for the U.S. Department of the Interior, Minerals Management Service. 109 pp + appendices.

Bloom, S.A. 1994. The community analyses system 4.2. Ecological Data Consultants, Inc., Archer, Florida.

Boschung, H.V. and G. Gunter. 1962. Distribution and variation of *Branchiostoma caribaeum* in Mississippi Sound. Tulane Studies in Zoology. 9: 245-257.

Brown, A.C. and A. McLachlan. 1990. Ecology of Sandy Shores. Elsevier, Amsterdam, The Netherlands. 328 pp.

Cary, L.A. 1996. The natural history of a sand dwelling amphipod, Eudevenopus honduranus Thomas & Barnard, 1983, from high energy beaches of east central Florida. Master Thesis, Florida Institute of Technology. 85 pp.

Charleston ODMDS Site Management and Monitoring Plan, 1993. Site Management and Monitoring Team (SMMP); U.S. Environmental Protection Agency, Region IV; the Charleston District U.S. Army Corps of Engineers; the U.S. Fish and Wildlife Service; the South Carolina Wildlife and Marine Resources Department; the South Carolina Ports Authority. Approved by LCDR Mark E. Vincent, USACE, and W. Ray Cunningham, Director, Water Management Division, USEPA, Region IV, March 10, 1993, 15 pp.

Clarke, D. and T. Miller-Way. 1992. An environmental assessment of the effects of open-water disposal of maintenance dredged material on benthic resources in Mobile Bay, Alabama. Final Report submitted to US Army Engineer District, Mobile. Misc. Paper D-92-1.

Cory, R.L. and E.L. Pierce. 1967. Distribution and ecology of lancelets (Order Amphioxi) over the continental shelf of the Southeastern United States. Limnology and Oceanography 12: 650-656.

Dauer, D.M., C.A. Maybury, and R.M. Ewing. 1981. Feeding behavior and general ecology of several spionid polychaetes from the Chesapeake Bay. Journal of Experimental Marine Biology and Ecology 54: 21-38.

Environmental Protection Agency. 1983. Final Environmental Impact Statement for Savannah, GA; Charleston, SC; and Wilmington, NC. Ocean Dredged Material Disposal Sites Designation. EPA Report. 440/2-83-014. 131 pp.

Fauchald, K. and P.A. Jumars. 1979. The diet of worms: a study of polychaete feeding guilds. Oceanography and Marine Biology Annual Reveiw. 17: 193-284.

Folk, R.L. 1980. Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, Texas. 185 pp.

Fortner, A.R., M. Sanders, and S.W. Lemire. 1996. Polynuclear aromatic hydrocarbons and trace metal burdens in sediment and the oyster, Crassostrea virginica (Gmelin), from two high salinity estuaries in South Carolina. In: Sustainable Development in the Southeast Coastal Zone. F.J. Vernberg, W.B. Vernberg and T. Siewicki, eds. University of South Carolina Press, Columbia, SC, USA, pp. 445-477.

Gayes, P.T. 2001. Geophysical characterization of the seafloor within the Charleston ocean dredged material disposal site, March-September 2000. Final report prepared by the Center for Marine and Wetland Studies for the South Carolina Department of Natural Resources. 49 pp.

Gayes, P.T., G.Y. Ojeda, P.C. Jutte, and R.F. Van Dolah. 2002. Geophysical characterization of the seafloor: Charleston ocean dredged material disposal site—July 2001. Final report prepared by the Center for Marine and Wetland Studies and the South Carolina Department of Natural Resources for the U.S. Army Corps of Engineers, Charleston District. 54 pp.

Harry, H.W. 1966. Studies on bivalve molluscs of the genus Crassinella in the Northwestern Gulf of Mexico: anatomy, ecology, and systematics. Publications of the Institute of Marine Science, University of Texas. 11:65-89.

Jutte, P.C., R.F. Van Dolah, M.V. Levisen, P. Donovan-Ealy, P.T. Gayes, and W.E. Baldwin. 1999. An environmental monitoring study of the Myrtle Beach renourishment project: physical and biological assessment of offshore sand borrow site, Phase I—Cherry Grove borrow area. Final report prepared by the South Carolina Department of Natural Resources for the U.S. Army Corps of Engineers, Charleston District. 79 pp.

Jutte, P.C., M.V. Levisen, and R.F. Van Dolah. 2001. Analysis of sediments and habitat in the areas surrounding the Charleston ocean dredged material disposal site, including unauthorized disposal operations. Final report prepared by the South Carolina Department of Natural Resources for the Norfolk Dredging Company and the U.S. Army Corps of Engineers. 21 pp.

Krahn, M.M., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Boger, W.D. McLeod, Jr., S.L. Chan, and D.W. Brown. 1988. New HPLC cleanup and revised extraction procedures for organic contaminants, National Oceanic and Atmospheric Administration Technical Memorandum NMFS F/NWC-153: 23-47.

Kucklick, J.R., S. Sivertsen, M. Sanders and G. Scott. 1997. Factors influencing polycyclic aromatic hydrocarbon concentrations and patterns in South Carolina sediments. Journal of Experimental Marine Biology and Ecology. 213: 13-29.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memo. NOS OMA 52. US National Oceanic and Atmospheric Administration, Seattle, Washington. 175pp.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19(1): 81-97.

Long, E.R. G.I. Scott, J. Kucklick, M. Fulton, B. Thompson, R.S. Carr, K.J. Scott, G.B. Thursby, G.T. Chandler, J.W. Anderson, G.M. Sloane. 1998. Final Report. Magnitude and extent of sediment toxicity in selected estuarines of South Carolina and Georgia. NOAA Technical Memorandum NOS ORCA: 178pp.

Luoma, S.N. 1989. Can we determine the biological availability of sediment-bound trace metals. Hydrobiologica. 176/177:379-396.

McDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology. 5:253-278.

Noakes, S. 1995. Postdisposal areal mapping of sediment chemistry at the Charleston, South Carolina ODMDS's. Final Report, submitted to U.S. Environmnental Protection Agency, Office of Wetlands, Oceans, and Watersheds. Prepared by the Center for Applied Isotope Studies, Athen GA. 56 pp.

Noakes, S. 2001. Postdisposal areal mapping of sediment chemistry at the Charleston, South Carolina ODMDS. Final report prepared by the Center for Applied Isotope Studies for the South Carolina Department of Natural Resources. 60 pp. + appendices.

Olsen, C.R., N.H. Cutshall, I.L. Larsen. 1982. Pollutant-particle associations and dynamics in coastal marine environments: a review. Marine Chemistry. 11:501-533.

Pequegnat, W.E., L.H. Pequegnat, B.M. James, E.A. Kennedy, R.R. Fay, and A.D. Fredericks. 1981. Procedural guide for designation surveys of ocean dredged material disposal sites. Final Report prepared by TerEce Corp. for U.S. Army Engineer Waterways Experiment Station, Technical Report EL-81-1, 268 pp.

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. Tech. Rept. EPA ICE-81-1, prepared by Great Lakes Laboratory, State University College at Buffalo, NY, for the U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredge and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Porter, James W. 1993. The Physiological Effects of Dredge-Spoil on the Oxygen Metabolism of Charleston Harbor, SC, Marine Benthic Invertebrates. Final Report, submitted to the United States Environmental Protection Agency, Region 4. Prepared by the Institute of Ecology, University of Georgia. 33 pp.

Ringwood, A.H., R.F. Van Dolah, A.F. Holland, and M.E. DeLorenzo. 1995. Year one demonstration project studies conducted in the Carolinian Province by Marine Resources Research Institute: results and summaries. Final Report submitted to National Oceanic and Atmospheric Administration.

South Carolina Wildlife and Marine Resources Division (SCWMRD). 1979. Benthic and sedimentological studies on the Charleston Harbor ocean disposal area, Charleston Harobr deepening project. Final report prepared for the U.S. Army Corps of Engineers, Charleston District.

Statistical Product and Software Solutions (SPSS). 1997. SigmaStat 2.0 for Windows. SPSS, Inc. Chicago, Illinois.

Steele-Petrovic, H.M. 1975. An explanation for the tolerance of brachipods and relative intolerance of bivalves for soft muddy bottoms. Journal of Paleontology. 49: 552-556.

Thomas, J.D. and J.L. Barnard. 1983. The Platyischnopidae of North America (Crustacea: Amphipoda). Smithsonian Contributions to Zoology. Number 375. Smithsonian Institution Press, City of Washington.

Van Dolah, R.F., D.R. Calder, and D.M. Knott. 1983. Assessment of benthic macrofauna in an ocean disposal area near Charleston, South Carolina. South Carolina Marine Resources Center Technical Report No. 56. 97 pp.

Van Dolah, R.F., P.H. Wendt, D.A. Goldman, and M.V. Levisen. 1996. Survey of benthic infaunal assemblages and sediment characteristics in and around the Charleston Ocean Dredged Material Disposal Area. Interim Report submitted to the U.S. Army Corps of Engineers, Charleston District. 57 pp. + appendices.

Van Dolah, R.F., P.H. Wendt, D.A. Goldman, A.B. Wrona, R.A. Pardieck, and M.V.

Levisen. 1997. An assessment of benthic infaunal assemblages and sediments in the vicinity of the Charleston Ocean Dredged Material Disposal Area. Final Report submitted to U.S. Army Corps of Engineers, Charleston District. 59pp.

Voulgaris, G. 2002. Disposal material mobility and transport in the vicinity of the Charleston Ocean Dredged Material Disposal Site. Final Report submitted to South Carolina Department of Natural Resources. 21 pp.

Wenner, C.A., C.A. Barans, B.W. Stender, F.H. Berry. 1979. Results of MARMAP otter trawl investigations in the South Atlantic Bight. III. Summer 1974. Technical Report –S.C. Marine Resources Center. 1979. 62 pp. Technical Report No. 41.

Wenner, C.A. C.A. Barans, B.W. Stender, F.H. Berry. 1980. Results of MARMAP otter trawls investigations in the South Atlantic Bight. V. Summer, 1975. S.C. Marine Resources Center Technical Report 45. 57 pp.

Wenner, E.L. and T.H. Read. 1981. Distribution and assemblages of decapod crustaceans from the continental shelf of the South Atlantic Bight: 1977-1979 MARMAP investigations. South Carolina Marine Resources Research Institute, Technical Report No. 49. 41 pp.

Williams, R., C. Sun, R. Bourgerie. 1997. Collection of ocean current data at the Charleston, South Carolina Ocean Dredged Material Disposal Site. Final Report submitted to the U.S. Environmental Protection Agency. Prepared by the National Oceanic and Atmospheric Administration, National Ocean Service, Coastal and Estuarine Oceanography Branch. 13 pp.

Wilmot, W.H. 1988. Charleston Harbor oceanography project phase 2 plan. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Oceanography and Marine Assessment.

Winn, R.H. R.F. Van Dolah, A. Frankenburg, and T. Kanna. 1989. Benthic and sedimentological studies of the ocean dredged material disposal site for Charleston, South Carolina. Vol. I-II. Final Report submitted to the U.S. Army Corps of Engineers, Charleston District.

APPENDICES

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
DA05	9601	09/12/2000	12.8	32.6518	79.7536
DA17	9602	09/12/2000	11.3	32.6466	79.7543
DA18	9603	09/12/2000	13.2	32.6483	79.7514
DA19	9604	09/12/2000	12.6	32.6466	79.7479
DA22	9605	09/12/2000	13.7	32.6433	79.7564
DA23	9606	09/12/2000	12.7	32.6436	79.7534
DA25	9607	09/12/2000	13.1	32.6450	79.7497
DA26	9608	09/12/2000	12.6	32.6421	79.7547
DA28	9609	09/12/2000	13.4	32.6433	79.7512
DA30	9610	09/12/2000	12.7	32.6410	79.7485
DB11	9611	09/12/2000	13.1	32.6432	79.7395
DB13	9612	09/12/2000	12.2	32.6414	79.7309
DB19	9613	09/12/2000	11.3	32.6411	79.7330
DB33	9614	09/12/2000	12.3	32.6332	79.7364
DB24	9615	09/12/2000	13.1	32.6386	79.7397
DB25	9616	09/12/2000	12.4	32.6383	79.7347
DB28	9617	09/12/2000	13.9	32.6360	79.7419
DB29	9618	09/12/2000	12.3	32.6458	79.7377
DB30	9619	09/12/2000	12.0	32.6351	79.7351
DB31	9620	09/12/2000	11.9	32.6366	79.7321
DC06	9621	09/12/2000	11.3	32.6315	79.7466
DC07	9622	09/12/2000	10.9	32.6316	79.7433
DC11	9623	09/12/2000	11.5	32.6300	79.7465
DC12	9624	09/12/2000	12.1	32.6298	79.7433
DC16	9625	09/12/2000	11.8	32.6265	79.7500
DC17	9626	09/12/2000	12.8	32.6265	79.7466
DC18	9627	09/12/2000	12.5	32.6282	79.7451
DC25	9628	09/12/2000	12.5	32.6265	79.7451
DC29	9629	09/12/2000	14.6	32.6233	79.7484
DC33	9630	09/12/2000	13.4	32.6216	79.7468
DD08	9631	09/12/2000	13.1	32.6378	79.7545
DD11	9632	09/12/2000	13.9	32.6371	79.7597
DD20	9633	09/12/2000	11.5	32.6334	79.7562
DD13	9634	09/12/2000	13.3	32.6349	79.7564
DD14	9635	09/12/2000	10.7	32.6371	79.7531
DD18	9636	09/12/2000	12.6	32.6331	79.7613
DD24	9637	09/12/2000	13.3	32.6318	79.7648
DD25	9638	09/12/2000	11.6	32.6313	79.7620
DD26	9639	09/12/2000	13.5	32.6316	79.7600
DD30	9640	09/12/2000	12.4	32.6298	79.7615
IA01	9641	09/11/2000	12.0	32.6549	79.7460
IA02	9642	09/11/2000	12.0	32.6668	79.7580
IA03	9643	09/11/2000	11.9	32.6670	79.7564
IA06	9644	09/11/2000	11.1	32.6633	79.7513
IA08	9645	09/11/2000	12.0	32.6605	79.7565
IA09	9646	09/11/2000	11.3	32.6618	79.7551
IA17	9647	09/11/2000	11.4	32.6599	79.7414
IA20	9648	09/11/2000	12.0	32.6564	79.7512
IA26	9649	09/11/2000	11.9	32.6547	79.7449
IA27	9650	09/11/2000	11.7	32.6547	79.7416

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
IB04	9651	09/11/2000	13.1	32.6517	79.7333
IB05	9652	09/11/2000	12.8	32.6535	79.7365
IB07	9653	09/11/2000	12.0	32.6518	79.7265
IB10	9654	09/11/2000	12.0	32.6500	79.7361
IB12	9655	09/11/2000	12.3	32.6516	79.7316
IB13	9656	09/11/2000	12.8	32.6519	79.7299
IB17	9657	09/11/2000	12.0	32.6480	79.7321
IB21	9658	09/11/2000	15.1	32.6481	79.7239
IB22	9659	09/11/2000	13.1	32.6484	79.7214
IB26	9660	09/11/2000	13.1	32.6467	79.7282
IC03	9661	09/11/2000	12.2	32.6434	79.7230
IC05	9662	09/11/2000	11.0	32.6415	79.7199
IC06	9663	09/11/2000	11.7	32.6420	79.7167
IC07	9664	09/11/2000	11.4	32.6402	79.7261
IC08	9665	09/11/2000	10.9	32.6400	79.7248
IC12	9666	09/11/2000	11.2	32.6366	79.7261
IC19	9667	09/11/2000	12.3	32.6367	79.7200
IC22	9668	09/11/2000	11.2	32.6337	79.7285
IC24	9669	09/11/2000	10.7	32.6338	79.7220
IC32	9670	09/12/2000	13.9	32.6267	79.7266
ID04	9671	09/12/2000	13.1	32.6252	79.7348
ID05	9672	09/12/2000	13.7	32.6250	79.7316
ID10	9673	09/12/2000	15.5	32.6232	79.7280
ID13	9674	09/12/2000	14.3	32.6200	79.7331
ID15	9675	09/12/2000	14.4	32.6166	79.7399
ID16	9676	09/12/2000	14.7	32.6184	79.7383
ID17	9677	09/12/2000	14.7	32.6183	79.7318
ID18	9678	09/12/2000	13.9	32.6201	79.7300
ID23	9679	09/12/2000	13.4	32.6168	79.7317
ID31	9680	09/12/2000	15.1	32.6102	79.7384
IE04	9681	09/12/2000	15.3	32.6181	79.7584
IE06	9682	09/12/2000	15.1	32.6181	79.7550
IE10	9683	09/12/2000	14.1	32.6163	79.7588
IE11	9684	09/12/2000	14.4	32.6163	79.7566
IE13	9685	09/12/2000	14.7	32.6165	79.7532
IE14	9686	09/12/2000	15.4	32.6150	79.7483
IE16	9687	09/12/2000	14.5	32.6148	79.7602
IE18	9688	09/12/2000	14.0	32.6132	79.7533
IE27	9689	09/12/2000	13.0	32.6100	79.7516
IE30	9690	09/12/2000	13.2	32.6118	79.7432
IF03	9691	09/12/2000	12.7	32.6265	79.7835
IF04	9692	09/12/2000	13.5	32.6283	79.7799
IF05	9693	09/12/2000	13.4	32.6283	79.7782
IF06	9694	09/12/2000	12.3	32.6266	79.7733
IF10	9695	09/12/2000	13.5	32.6249	79.7816
IF13	9696	09/12/2000	12.6	32.6266	79.7749
IF22	9697	09/12/2000	12.3	32.6231	79.7701
IF27	9698	09/12/2000	13.1	32.6199	79.7735
IF29	9699	09/12/2000	12.6	32.6217	79.7683
IF30	9700	09/12/2000	13.5	32.6216	79.7653

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
IG03	9701	09/12/2000	15.5	32.6451	79.7763
IG08	9702	09/12/2000	13.4	32.6416	79.7745
IG11	9703	09/12/2000	14.3	32.6400	79.7765
IG07	9704	09/12/2000	13.8	32.6438	79.7765
IG19	9705	09/12/2000	14.1	32.6366	79.7818
IG25	9706	09/12/2000	15.5	32.6333	79.7833
IG27	9707	09/12/2000	13.1	32.6332	79.7743
IG29	9708	09/12/2000	14.5	32.6316	79.7848
IG30	9709	09/12/2000	12.9	32.6316	79.7781
IG32	9710	09/12/2000	14.4	32.6300	79.7867
IH03	9711	09/12/2000	12.2	32.6628	79.7650
IH04	9712	09/12/2000	12.5	32.6633	79.7614
IH05	9713	09/12/2000	12.3	32.6619	79.7667
IH20	9714	09/12/2000	13.3	32.6515	79.7631
IH09	9715	09/12/2000	13.1	32.6600	79.7645
IH12	9716	09/12/2000	13.2	32.6566	79.7667
IH15	9717	09/12/2000	14.1	32.6551	79.7678
IH18	9718	09/12/2000	13.8	32.6537	79.7681
IH19	9719	09/12/2000	13.7	32.6538	79.7667
IH28	9720	09/12/2000	14.0	32.6483	79.7696
OA02	9721	09/11/2000	10.5	32.6784	79.7616
OA03	9722	09/11/2000	11.6	32.6750	79.7617
OA04	9723	09/11/2000	10.4	32.6750	79.7566
OA05	9724	09/11/2000	10.7	32.6751	79.7584
OA07	9725	09/11/2000	10.9	32.6732	79.7597
OA08	9726	09/11/2000	10.8	32.6730	79.7584
OA27	9727	09/11/2000	11.5	32.6667	79.7448
OA28	9728	09/11/2000	12.1	32.6651	79.7430
OA31	9729	09/11/2000	10.9	32.6648	79.7368
OA32	9730	09/11/2000	11.2	32.6636	79.7385
OB04	9731	09/11/2000	11.4	32.6617	79.7321
OB09	9732	09/11/2000	13.1	32.6601	79.7324
OB10	9733	09/11/2000	12.7	32.6582	79.7272
OB19	9734	09/11/2000	14.0	32.6566	79.7168
OB25	9735	09/11/2000	12.3	32.6546	79.7171
OB26	9736	09/11/2000	13.1	32.6550	79.7131
OB32	9737	09/11/2000	13.0	32.6514	79.7103
OB35	9738	09/11/2000	12.5	32.6514	79.7149
OB36	9739	09/11/2000	12.3	32.6519	79.7078
OB38	9740	09/11/2000	14.0	32.6501	79.7046
OC04	9741	09/11/2000	12.6	32.6451	79.7046
OC05	9742	09/11/2000	13.0	32.6438	79.7081
OC10	9743	09/11/2000	12.0	32.6382	79.7100
OC12	9744	09/11/2000	12.2	32.6388	79.7148
OC13	9745	09/11/2000	11.6	32.6365	79.7082
OC16	9746	09/11/2000	11.4	32.6374	79.7129
OC24	9747	09/11/2000	11.9	32.6302	79.7168
OC25	9748	09/11/2000	11.9	32.6301	79.7118
OC30	9749	09/11/2000	13.8	32.6255	79.7232
OC32	9750	09/11/2000	14.5	32.6248	79.7183

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
OD02	9751	09/11/2000	15.4	32.6235	79.7251
OD04	9752	09/11/2000	15.0	32.6198	79.7202
OD13	9753	09/11/2000	14.8	32.6148	79.7250
OD14	9754	09/11/2000	15.1	32.6149	79.7300
OD18	9755	09/11/2000	14.5	32.6115	79.7303
OD28	9756	09/11/2000	14.3	32.6069	79.7353
OD29	9757	09/11/2000	14.3	32.6066	79.7267
OD33	9758	09/11/2000	14.1	32.6035	79.7334
OD36	9759	09/11/2000	13.8	32.5996	79.7350
OD38	9760	09/11/2000	13.7	32.5984	79.7332
OE06	9761	09/11/2000	13.4	32.6083	79.7649
OE07	9762	09/11/2000	13.0	32.6103	79.7634
OE08	9763	09/11/2000	14.6	32.6069	79.7600
OE09	9764	09/11/2000	13.6	32.6088	79.7550
OE12	9765	09/11/2000	14.4	32.6050	79.7549
OE13	9766	09/11/2000	13.7	32.6070	79.7516
OE18	9767	09/11/2000	15.1	32.6032	79.7537
OE19	9768	09/11/2000	15.1	32.6051	79.7518
OE24	9769	09/11/2000	14.2	32.6021	79.7446
OE29	9770	09/11/2000	15.9	32.6003	79.7380
OF03	9771	09/11/2000	13.7	32.6235	79.7984
OF05	9772	09/11/2000	13.4	32.6235	79.7915
OF06	9773	09/11/2000	11.6	32.6234	79.7869
OF18	9774	09/11/2000	13.0	32.6200	79.7765
OF22	9775	09/11/2000	14.5	32.6166	79.7781
OF23	9776	09/11/2000	15.1	32.6170	79.7749
OF26	9777	09/11/2000	13.7	32.6153	79.7817
OF30	9778	09/11/2000	13.6	32.6150	79.7699
OF35	9779	09/11/2000	14.5	32.6135	79.7700
OF37	9780	09/11/2000	13.0	32.6099	79.7700
OG02	9781	09/11/2000	14.8	32.6483	79.7801
OG03	9782	09/11/2000	13.9	32.6525	79.7833
OG09	9783	09/11/2000	14.3	32.6469	79.7849
OG10	9784	09/11/2000	14.9	32.6450	79.7833
OG15	9785	09/11/2000	16.0	32.6418	79.7848
OG22	9786	09/11/2000	14.1	32.6367	79.7848
OG23	9787	09/11/2000	14.9	32.6352	79.7919
OG08	9788	09/11/2000	14.0	32.6456	79.7883
OG29	9789	09/11/2000	14.9	32.6301	79.7983
OG33	9790	09/11/2000	13.8	32.6286	79.7967
OH01	9791	09/11/2000	12.8	32.6602	79.7720
OH02	9792	09/11/2000	10.7	32.6784	79.7666
OH05	9793	09/11/2000	11.9	32.6736	79.7667
OH06	9794	09/11/2000	12.2	32.6720	79.7694
OH10	9795	09/11/2000	11.2	32.6702	79.7678
OH12	9796	09/11/2000	11.7	32.6667	79.7713
OH14	9797	09/11/2000	12.2	32.6566	79.7737
OH15	9798	09/11/2000	11.9	32.6649	79.7745
OH27	9799	09/11/2000	13.4	32.6541	79.7812
OH30	9800	09/11/2000	14.4	32.6522	79.7783

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
DA05	9/12/2000	62.9	0.8	36.3	0.7	2.1	F	0.682	MW	2.5
DA17	9/12/2000	70.2	1.4	28.4	0.8	2.1	F	0.530	MW	2.5
DA18	9/12/2000	77.5	4.4	18.1	1.0	2.8	F	0.577	MW	3.0
DA19	9/12/2000	90.7	2.4	6.9	0.7	2.8	F	0.415	W	3.0
DA22	9/12/2000	72.5	8.4	19.1	1.6	2.8	F	0.579	MW	3.0
DA23	9/12/2000	53.6	1.7	44.7	0.9	1.4	M	1.029	P	1.5
DA25	9/12/2000	85.3	3.1	11.6	0.9	2.7	F	0.541	MW	3.0
DA26	9/12/2000	77.8	5.8	16.5	1.1	2.6	F	0.630	MW	3.0
DA28	9/12/2000	26.9	67.8	5.3	8.7	3.2	VF	0.480	W	3.5
DA30	9/12/2000	88.6	4.5	6.9	0.8	2.8	F	0.480	W	3.0
Mean		**70.6**	**10.0**	**19.4**	**1.7**	**2.5**				
DB11	9/12/2000	80.4	9.2	10.4	2.2	2.5	F	0.485	W	3.0
DB13	9/12/2000	53.0	4.5	42.5	0.9	2.2	F	0.707	MW	3.0
DB19	9/12/2000	12.8	3.1	84.1	0.9	1.9	M	1.055	P	2.0
DB24	9/12/2000	88.6	2.3	9.1	0.8	2.5	F	0.478	W	3.0
DB25	9/12/2000	33.8	3.9	62.3	0.7	1.8	M	0.652	MW	2.0
DB28	9/12/2000	59.9	29.1	11.1	5.7	2.6	F	0.520	MW	3.0
DB29	9/12/2000	32.1	3.2	64.7	0.7	1.9	M	0.780	M	2.0
DB30	9/12/2000	81.7	1.1	17.1	0.6	1.9	M	0.707	MW	2.5
DB31	9/12/2000	53.3	4.3	42.4	1.2	2.2	F	0.754	M	2.5
DB33	9/12/2000	76.9	6.7	16.4	0.8	2.5	F	0.532	MW	3.0
Mean		**57.3**	**6.7**	**36.0**	**1.5**	**2.2**				
DC06	9/12/2000	52.9	24.4	22.7	6.3	2.9	F	0.744	M	3.0
DC07	9/12/2000	92.4	1.7	5.9	0.7	2.6	F	0.404	W	3.0
DC11	9/12/2000	83.9	3.3	12.8	0.8	2.5	F	0.536	MW	3.0
DC12	9/12/2000	80.3	1.4	18.2	1.4	2.4	F	0.557	MW	2.5
DC16	9/12/2000	87.5	1.3	11.2	0.8	2.5	F	0.550	MW	3.0
DC17	9/12/2000	59.7	28.8	11.5	7.1	2.5	F	0.559	MW	3.0
DC18	9/12/2000	80.0	2.4	17.6	0.7	2.4	F	0.528	MW	3.0

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
DC25	9/12/2000	60.6	3.4	36.1	0.8	1.8	M	1.029	P	2.5
DC29	9/12/2000	79.7	1.1	19.2	0.8	1.7	M	0.862	M	1.5
DC33	9/12/2000	32.9	8.0	59.1	0.8	1.8	M	0.669	MW	2.0
Mean		**71.0**	**7.6**	**21.4**	**2.0**	**2.3**				
DD08	9/12/2000	36.4	58.1	5.5	6.5	3.2	VF	0.540	MW	3.5
DD11	9/12/2000	82.4	3.0	14.5	1.1	2.7	F	0.644	MW	3.0
DD13	9/12/2000	69.6	6.4	24.0	1.4	2.2	F	1.555	P	3.0
DD14	9/12/2000	27.6	63.4	8.9	6.1	2.9	F	0.651	MW	3.0
DD18	9/12/2000	77.1	2.2	20.7	0.8	1.6	M	0.891	M	2.0
DD20	9/12/2000	56.2	36.8	7.0	3.6	2.7	F	0.611	MW	3.0
DD24	9/12/2000	87.6	3.0	9.4	1.0	2.4	F	0.615	MW	3.0
DD25	9/12/2000	82.2	1.7	16.1	0.7	2.1	F	0.732	M	2.5
DD26	9/12/2000	77.6	6.6	15.8	2.3	2.7	F	0.650	MW	3.0
DD30	9/12/2000	85.9	0.7	13.4	0.9	2.5	F	0.588	MW	3.0
Mean		**68.3**	**18.2**	**13.5**	**2.4**	**2.5**				
IA01	9/11/2000	87.5	2.7	9.8	0.8	2.6	F	0.526	MW	3.0
IA02	9/11/2000	92.3	0.5	7.2	0.7	2.5	F	0.446	W	3.0
IA03	9/11/2000	90.2	1.1	8.7	0.7	2.4	F	0.507	MW	2.5
IA06	9/11/2000	90.0	2.3	7.7	0.6	2.4	F	0.496	W	2.5
IA08	9/11/2000	88.5	2.4	9.2	0.7	2.7	F	0.414	W	3.0
IA09	9/11/2000	88.5	1.5	10.0	0.7	2.5	F	0.520	MW	3.0
IA17	9/11/2000	83.7	1.8	14.5	0.8	2.4	F	0.481	W	3.0
IA20	9/11/2000	77.7	4.7	17.6	0.8	2.6	F	0.669	MW	3.0
IA26	9/11/2000	85.9	2.1	12.0	0.8	2.5	F	0.478	W	3.0
IA27	9/11/2000	76.8	1.5	21.8	0.7	2.1	F	0.662	MW	2.5
Mean		**86.1**	**2.0**	**11.9**	**0.7**	**2.5**				
IB04	9/11/2000	90.4	1.6	7.9	0.7	2.4	F	0.441	W	2.5
IB05	9/11/2000	87.0	1.7	11.2	0.7	2.4	F	0.498	W	3.0

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
IB07	9/11/2000	74.2	0.7	25.1	0.7	1.5	M	0.764	M	1.5
IB10	9/11/2000	92.3	0.6	7.0	0.7	2.5	F	0.427	W	3.0
IB12	9/11/2000	78.4	1.0	20.6	0.7	1.8	M	0.752	M	2.5
IB13	9/11/2000	87.4	1.4	11.2	0.7	2.3	F	0.497	W	2.5
IB17	9/11/2000	85.5	1.7	12.8	0.7	2.3	F	0.472	W	2.5
IB21	9/11/2000	83.9	3.4	12.7	0.7	2.4	F	0.662	MW	3.0
IB22	9/11/2000	78.7	1.8	19.5	0.7	2.4	F	0.502	MW	3.0
IB26	9/11/2000	83.5	1.5	15.0	0.7	2.3	F	0.457	W	2.5
Mean		**84.1**	**1.5**	**14.3**	**0.7**	**2.2**				
IC03	9/11/2000	82.1	2.0	15.8	0.6	2.3	F	0.555	MW	2.5
IC05	9/11/2000	68.1	1.5	30.4	0.7	2.0	F	0.490	W	2.5
IC06	9/11/2000	73.9	1.6	24.5	0.6	2.2	F	0.530	MW	2.5
IC07	9/11/2000	91.9	1.2	6.9	0.6	2.3	F	0.363	W	2.5
IC08	9/11/2000	77.7	1.2	21.1	0.6	1.9	M	0.511	MW	2.0
IC12	9/11/2000	88.7	1.3	10.0	0.6	2.3	F	0.465	W	2.5
IC19	9/11/2000	82.7	1.9	15.5	0.6	2.2	F	0.516	MW	2.5
IC22	9/11/2000	62.2	1.9	35.9	0.6	1.8	M	0.604	MW	2.0
IC24	9/11/2000	63.0	1.7	35.3	0.7	1.6	M	0.677	MW	2.0
IC32	9/12/2000	86.6	2.4	11.0	0.7	2.5	F	0.421	W	3.0
Mean		**77.7**	**1.7**	**20.6**	**0.7**	**2.1**				
ID04	9/12/2000	73.2	1.9	24.9	0.8	1.5	M	0.813	M	2.0
ID05	9/12/2000	90.5	1.6	7.8	0.7	2.6	F	0.390	W	3.0
ID10	9/12/2000	89.4	0.8	9.8	0.8	2.7	F	0.371	W	3.0
ID13	9/12/2000	63.9	1.7	34.5	0.7	1.1	M	1.080	P	1.0
ID15	9/12/2000	89.0	1.9	9.2	0.6	0.3	C	0.945	M	0.5
ID16	9/12/2000	89.7	1.5	8.8	0.7	2.2	F	0.711	M	3.0
ID17	9/12/2000	51.1	2.5	46.5	1.0	1.8	M	1.047	P	3.0
ID18	9/12/2000	87.7	1.9	10.3	0.7	2.4	F	0.486	W	3.0
ID23	9/12/2000	69.5	2.4	28.1	0.7	2.0	M	0.609	MW	2.5

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
ID31	9/12/2000	90.5	0.2	9.2	0.6	2.0	F	0.705	MW	2.5
Mean		**79.5**	**1.6**	**18.9**	**0.7**	**1.9**				
IE04	9/12/2000	60.7	6.2	33.1	1.1	1.3	M	0.991	M	1.0
IE06	9/12/2000	69.0	5.9	25.0	1.1	1.0	C	1.677	P	3.0
IE10	9/12/2000	89.0	2.5	8.4	0.7	2.5	F	0.499	W	3.0
IE11	9/12/2000	91.3	1.4	7.3	0.7	2.5	F	0.503	MW	3.0
IE13	9/12/2000	78.7	0.6	20.7	0.8	2.1	F	1.176	P	3.0
IE14	9/12/2000	81.6	3.0	15.4	0.8	1.8	M	1.339	P	2.5
IE16	9/12/2000	56.6	2.2	41.2	1.1	1.9	M	0.789	M	2.5
IE18	9/12/2000	61.9	0.7	37.4	0.8	1.5	M	1.325	P	2.5
IE27	9/12/2000	88.4	3.1	8.5	0.6	2.3	F	0.494	W	2.5
IE30	9/12/2000	85.9	2.2	11.9	0.6	2.3	F	0.494	W	2.5
Mean		**76.3**	**2.8**	**20.9**	**0.8**	**1.9**				
IF03	9/12/2000	89.0	2.4	8.6	0.7	2.6	F	0.486	W	3.0
IF04	9/12/2000	85.0	2.7	12.3	1.2	2.6	F	0.527	MW	3.0
IF05	9/12/2000	86.2	3.2	10.6	0.8	2.6	F	0.540	MW	3.0
IF06	9/12/2000	88.3	2.9	8.8	0.7	2.4	F	0.483	W	2.5
IF10	9/12/2000	86.4	1.8	11.7	0.8	2.5	F	0.595	MW	3.0
IF13	9/12/2000	86.2	1.4	12.4	0.7	2.2	F	0.648	MW	2.5
IF22	9/12/2000	87.8	2.7	9.6	0.7	2.4	F	0.542	MW	2.5
IF27	9/12/2000	89.1	3.2	7.6	0.7	2.4	F	0.554	MW	2.5
IF29	9/12/2000	84.7	0.9	14.5	0.6	1.6	M	0.792	M	2.0
IF30	9/12/2000	89.1	0.9	10.0	0.7	2.5	F	0.514	MW	3.0
Mean		**87.2**	**2.2**	**10.6**	**0.8**	**2.4**				
IG03	9/12/2000	73.0	11.0	16.0	2.2	2.9	F	0.547	MW	3.0
IG07	9/12/2000	49.2	30.4	20.4	5.4	3.4	VF	0.449	W	4.0
IG08	9/12/2000	88.5	1.9	9.6	0.8	2.5	F	0.541	MW	3.0
IG11	9/12/2000	82.1	4.4	13.4	1.0	2.8	F	0.491	W	3.0

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
IG19	9/12/2000	88.1	2.6	9.2	0.8	2.7	F	0.521	MW	3.0
IG25	9/12/2000	82.5	4.1	13.4	1.2	2.6	F	0.618	MW	3.0
IG27	9/12/2000	84.1	2.2	13.6	1.1	2.7	F	0.627	MW	3.0
IG29	9/12/2000	81.8	2.9	15.3	0.9	1.5	M	0.983	M	2.0
IG30	9/12/2000	88.3	1.6	10.0	0.8	2.3	F	0.588	MW	2.5
IG32	9/12/2000	92.8	1.3	6.0	0.9	2.4	F	0.495	W	2.5
Mean		**81.0**	**6.2**	**12.7**	**1.5**	**2.6**				
IH03	9/12/2000	90.3	0.8	8.9	0.8	2.5	F	0.422	W	3.0
IH04	9/12/2000	87.5	1.4	11.2	0.8	2.5	F	0.502	MW	3.0
IH05	9/12/2000	89.7	1.0	9.3	0.7	2.6	F	0.408	W	3.0
IH09	9/12/2000	82.1	6.3	11.6	0.9	2.6	F	0.424	W	3.0
IH12	9/12/2000	84.1	2.3	13.6	1.0	2.7	F	0.408	W	3.0
IH15	9/12/2000	84.4	2.0	13.6	0.9	2.8	F	0.403	W	3.0
IH18	9/12/2000	65.7	5.2	29.1	1.5	2.5	F	0.704	MW	3.0
IH19	9/12/2000	84.4	3.4	12.2	1.0	2.8	F	0.426	W	3.0
IH20	9/12/2000	76.4	8.8	14.8	2.2	2.7	F	0.578	MW	3.0
IH28	9/12/2000	67.4	7.7	24.9	1.5	2.6	F	0.912	M	3.0
Mean		**81.2**	**3.9**	**14.9**	**1.1**	**2.6**				
OA02	9/11/2000	79.9	3.7	16.4	0.8	2.2	F	0.541	MW	2.5
OA03	9/11/2000	87.2	3.1	9.7	0.7	2.5	F	0.475	W	3.0
OA04	9/11/2000	80.9	2.8	16.3	0.7	2.1	F	0.613	MW	2.5
OA05	9/11/2000	77.1	2.8	20.1	0.7	2.0	M	0.573	MW	2.0
OA07	9/11/2000	82.4	2.7	14.9	0.7	2.2	F	0.573	MW	2.5
OA08	9/11/2000	92.7	0.5	6.8	0.7	2.3	F	0.431	W	2.5
OA27	9/11/2000	86.3	0.9	12.8	0.7	2.5	F	0.474	W	3.0
OA28	9/11/2000	91.5	0.8	7.7	0.7	2.6	F	0.422	W	3.0
OA31	9/11/2000	56.7	1.5	41.9	0.8	1.5	M	0.840	M	1.5
OA32	9/11/2000	88.8	0.5	10.7	0.7	2.4	F	0.461	W	2.5
Mean		**82.4**	**1.9**	**15.7**	**0.7**	**2.2**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
OB04	9/11/2000	89.4	2.1	8.5	0.7	2.4	F	0.439	W	2.5
OB09	9/11/2000	60.8	11.5	27.7	1.8	2.4	F	0.698	MW	3.0
OB10	9/11/2000	84.1	3.8	12.2	0.8	2.5	F	0.429	W	3.0
OB19	9/11/2000	60.9	3.5	35.7	0.8	0.4	C	0.856	M	0.5
OB25	9/11/2000	45.5	3.3	51.2	1.0	1.2	M	0.953	M	1.0
OB26	9/11/2000	86.7	3.2	10.2	0.7	2.6	F	0.468	W	3.0
OB32	9/11/2000	86.0	2.3	11.7	0.7	2.2	F	0.519	MW	2.5
OB35	9/11/2000	83.3	2.6	14.1	0.8	2.2	F	0.568	MW	2.5
OB36	9/11/2000	85.1	2.6	12.2	0.7	2.4	F	0.453	W	3.0
OB38	9/11/2000	87.5	2.6	10.0	0.7	2.5	F	0.457	W	3.0
Mean		**76.9**	**3.7**	**19.3**	**0.9**	**2.1**				
OC04	9/11/2000	54.3	1.5	44.2	0.7	0.3	C	1.166	P	0.5
OC05	9/11/2000	75.4	1.7	22.9	0.7	1.0	C	1.025	P	1.0
OC10	9/11/2000	77.6	1.9	20.5	0.6	1.4	M	0.897	M	2.5
OC12	9/11/2000	77.6	2.1	20.3	0.7	2.2	F	0.476	W	2.5
OC13	9/11/2000	36.3	1.7	62.0	0.8	1.6	M	0.792	M	2.5
OC16	9/11/2000	64.8	2.1	33.1	0.8	1.6	M	0.804	M	2.5
OC24	9/11/2000	78.2	2.2	19.6	0.7	2.3	F	0.496	W	2.5
OC25	9/11/2000	81.6	1.7	16.7	0.7	2.3	F	0.418	W	2.5
OC30	9/11/2000	86.8	3.8	9.4	0.7	2.5	F	0.503	MW	3.0
OC32	9/11/2000	87.8	2.0	10.2	0.7	2.5	F	0.367	W	3.0
Mean		**72.0**	**2.1**	**25.9**	**0.7**	**1.8**				
OD02	9/11/2000	88.5	0.8	10.7	0.8	2.6	F	0.427	W	3.0
OD04	9/11/2000	89.9	1.2	8.9	0.7	2.6	F	0.394	W	3.0
OD13	9/11/2000	89.9	1.1	9.0	0.7	2.6	F	0.388	W	3.0
OD14	9/11/2000	88.1	0.9	11.0	0.8	2.5	F	0.480	W	3.0
OD18	9/11/2000	88.5	0.1	11.4	0.7	2.2	F	0.605	MW	0.5
OD28	9/11/2000	87.9	0.6	11.5	0.6	2.1	F	0.585	MW	2.5

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
OD29	9/11/2000	82.0	0.6	17.4	0.7	0.4	C	1.109	P	0.5
OD33	9/11/2000	87.7	0.9	11.4	0.7	2.2	F	0.471	W	2.5
OD36	9/11/2000	83.8	4.7	11.4	0.7	2.2	F	0.531	MW	2.5
OD38	9/11/2000	79.9	3.5	16.6	0.7	2.1	F	0.617	MW	2.5
Mean		**86.6**	**1.4**	**11.9**	**0.7**	**2.2**				
OE06	9/11/2000	66.2	2.8	31.0	0.8	1.6	M	0.969	M	2.5
OE07	9/11/2000	83.2	2.5	14.3	0.7	2.2	F	0.485	W	2.5
OE08	9/11/2000	80.7	1.6	17.7	0.7	0.6	C	1.156	P	0.5
OE09	9/11/2000	87.0	2.0	11.0	0.7	2.1	F	0.624	MW	2.5
OE12	9/11/2000	89.4	1.9	8.6	0.7	2.4	F	0.456	W	2.5
OE13	9/11/2000	86.0	0.9	13.2	0.7	2.2	F	0.481	W	2.5
OE18	9/11/2000	85.9	1.5	12.6	0.8	1.8	M	1.246	P	3.0
OE19	9/11/2000	90.5	1.0	8.5	0.7	2.5	F	0.437	W	3.0
OE24	9/11/2000	87.5	2.6	9.9	0.7	2.3	F	0.471	W	2.5
OE29	9/11/2000	71.8	2.6	25.6	0.8	1.8	M	0.925	M	2.5
Mean		**82.8**	**1.9**	**15.2**	**0.7**	**1.9**				
OF03	9/11/2000	70.3	4.2	25.5	1.2	2.1	F	1.372	P	3.0
OF05	9/11/2000	90.9	1.6	7.5	0.7	2.4	F	0.482	W	2.5
OF06	9/11/2000	93.0	0.5	6.5	0.7	2.3	F	0.486	W	2.5
OF18	9/11/2000	89.8	2.6	7.7	0.7	2.3	F	0.552	MW	2.5
OF22	9/11/2000	62.4	2.3	35.3	1.1	1.5	M	1.129	P	1.0
OF23	9/11/2000	58.2	1.8	40.0	1.1	1.4	M	1.106	P	1.0
OF26	9/11/2000	91.8	1.1	7.1	0.7	2.5	F	0.505	MW	3.0
OF30	9/11/2000	81.3	2.8	15.9	0.7	2.1	F	0.732	M	3.0
OF35	9/11/2000	81.8	7.2	11.0	0.7	2.3	F	0.572	MW	2.5
OF37	9/11/2000	52.8	3.1	44.1	0.8	1.2	M	1.198	P	2.0
Mean		**77.2**	**2.7**	**20.1**	**0.8**	**2.0**				
OG02	9/11/2000	83.8	5.2	11.0	1.0	2.9	F	0.414	W	3.0

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	$\bar{X}$	Size Class	SD	Sorting Descr.	Mode
OG03	9/11/2000	83.8	4.6	11.7	0.9	2.8	F	0.475	W	3.0
OG08	9/11/2000	84.9	4.5	10.6	0.9	2.8	F	0.477	W	3.0
OG09	9/11/2000	80.9	9.0	10.0	1.6	2.8	F	0.444	W	3.0
OG10	9/11/2000	71.7	15.6	12.8	3.3	3.0	F	0.461	W	3.0
OG15	9/11/2000	67.6	18.5	13.9	2.5	3.1	VF	0.466	W	3.0
OG22	9/11/2000	88.1	2.0	9.9	1.0	2.7	F	0.478	W	3.0
OG23	9/11/2000	79.2	12.0	8.7	3.2	2.5	F	0.537	MW	3.0
OG29	9/11/2000	74.3	3.8	21.9	0.8	0.9	C	1.060	P	1.0
OG33	9/11/2000	53.9	2.8	43.3	1.1	0.8	C	1.239	P	0.5
Mean		**76.8**	**7.8**	**15.4**	**1.6**	**2.4**				
OH01	9/11/2000	87.1	4.0	8.8	0.8	2.7	F	0.433	W	3.0
OH02	9/11/2000	84.8	7.4	7.8	0.7	2.4	F	0.503	MW	3.0
OH05	9/11/2000	89.4	5.2	5.4	0.7	2.4	F	0.462	W	2.5
OH06	9/11/2000	85.6	4.7	9.7	0.8	2.5	F	0.466	W	3.0
OH10	9/11/2000	87.1	5.7	7.2	0.7	2.4	F	0.471	W	3.0
OH12	9/11/2000	91.3	0.3	8.3	0.8	2.6	F	0.413	W	3.0
OH14	9/11/2000	83.4	0.4	16.2	1.1	2.6	F	0.601	MW	3.0
OH15	9/11/2000	88.0	3.0	9.0	0.8	2.7	F	0.355	W	3.0
OH27	9/11/2000	70.2	16.1	13.8	1.6	2.8	F	0.427	W	3.0
OH30	9/11/2000	83.4	4.1	12.5	1.1	2.8	F	0.468	W	3.0
Mean		**85.0**	**5.1**	**9.9**	**0.9**	**2.6**				

Appendix 3. Total abundance (#/ $0.04m^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Abra aequalis	M	14	0	0	0	3	1	1	1	0	0	8
Acanthohaustorius intermedius	A	182	27	10	21	25	36	10	4	36	0	13
Acanthohaustorius millsi	A	10	3	6	0	0	0	0	0	1	0	0
Acrocirridae	P	12	0	3	3	2	0	0	0	0	4	0
Acteocina candei	M	64	2	8	8	17	2	6	9	8	1	3
Acteocina sp.	M	10	7	0	2	0	0	0	1	0	0	0
Acteon candens	M	10	0	2	1	0	0	0	2	0	5	0
Acteon sp.	M	1	0	1	0	0	0	0	0	0	0	0
Actiniaria	O	25	4	3	4	1	3	5	1	*0*	4	0
Aglaophamus verrilli	P	64	0	0	0	0	1	14	9	0	28	12
Albunea gibbesii	O	6	0	0	0	2	2	0	1	1	0	0
Albunea paretii	O	1	0	0	0	0	0	1	0	0	0	0
Albunea sp.	O	1	1	0	0	0	0	0	0	0	0	0
Amastigos caperatus	P	1	0	0	0	0	0	0	0	0	1	0
Ampelisca abdita	A	2	0	0	0	0	0	1	0	0	1	0
Ampelisca agassizi	A	1	0	1	0	0	0	0	0	0	0	0
Ampelisca sp.	A	1	0	1	0	0	0	0	0	0	0	0
Ampelisca verrilli	A	1	0	0	0	1	0	0	0	0	0	0
Ampharetidae	P	10	1	3	1	0	0	1	4	0	0	0
Amphicteis gunneri	P	4	0	4	0	0	0	0	0	0	0	0
Amphiodia pulchella	O	46	1	8	3	0	0	2	0	0	32	0
Amphipoda	A	1	1	0	0	0	0	0	0	0	0	0
Anadara ovalis	M	1	0	0	0	0	0	0	0	1	0	0
Anadara sp.	M	3	0	3	0	0	0	0	0	0	0	0
Anadara transversa	M	35	0	21	0	0	0	0	4	3	7	0
Anadarinae	M	1	0	0	0	0	0	1	0	0	0	0
Ancinus depressus	O	6	2	0	1	0	1	0	0	2	0	0
Ancistrosyllis sp.	P	93	0	13	2	7	0	0	1	0	66	4
Anomia simplex	M	8	0	6	0	0	0	0	0	0	2	0
Aonides paucibranchiata	P	41	0	16	24	0	0	0	0	0	1	0
Aoridae	A	1	0	0	0	0	0	0	0	0	1	0
Apanthura magnifica	O	9	0	2	0	0	1	0	0	0	6	0
Aphealochaeta sp.	P	3	0	2	0	0	0	1	0	0	0	0
Arabella mutans	P	2	0	1	0	0	0	1	0	0	0	0
Arcidae	M	3	0	0	0	0	0	1	0	0	2	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Arene sp.	M	2	0	0	2	0	0	0	0	0	0	0
Aricidea sp. A	P	3	0	0	0	0	0	0	0	0	3	0
Aricidea lopezi	P	26	0	2	0	0	0	7	1	0	14	2
Aricidea philbinae	P	1	0	0	0	0	0	0	0	0	0	1
Aricidea sp.	P	1	1	0	0	0	0	0	0	0	0	0
Aricidea suecica	P	24	1	17	0	1	1	2	1	0	0	1
Aricidea wassi	P	49	0	4	0	0	2	0	17	5	1	20
Armandia agilis	P	129	3	3	1	12	1	10	33	3	36	27
Armandia maculata	P	152	15	42	34	7	4	8	14	8	16	4
Armandia sp.	P	2	0	0	0	2	0	0	0	0	0	0
Aspidosiphon albus	O	8	0	7	0	0	0	0	0	1	0	0
Aspidosiphon gosnoldi	O	102	2	26	12	7	0	10	3	2	34	6
Aspidosiphon sp.	O	1	1	0	0	0	0	0	0	0	0	0
Asteroidea	O	1	0	0	0	0	1	0	0	0	0	0
Astyris lunata	M	3	0	0	0	3	0	0	0	0	0	0
Autolytus sp.	P	14	0	10	2	0	0	0	0	1	1	0
Axiognathus squamatus	O	1	0	0	0	0	0	0	0	0	1	0
Axiothella mucosa	P	2	0	1	0	1	0	0	0	0	0	0
Axiothella sp.	P	2	0	0	0	2	0	0	0	0	0	0
Batea catharinensis	A	12	0	2	0	3	0	0	5	0	2	0
Bateidae	A	3	0	3	0	0	0	0	0	0	0	0
Bathyporeia parkeri	A	58	1	4	7	19	11	1	6	4	0	5
Bathyporeia sp.	A	1	0	0	0	1	0	0	0	0	0	0
Bhawania heteroseta	P	231	1	39	5	0	0	0	0	1	185	0
Bhawania sp.	P	1	0	0	1	0	0	0	0	0	0	0
Biffarius biformis	O	6	0	0	0	0	0	0	1	0	2	3
Brachyura	O	10	0	0	0	1	4	0	0	0	5	0
Branchiostoma sp.	O	736	129	242	180	95	11	12	4	48	11	4
Branchiosyllis exilis	P	1	1	0	0	0	0	0	0	0	0	0
Brania sp.	P	25	3	5	15	0	0	0	0	0	2	0
Brania wellfleetensis	P	13	4	2	3	4	0	0	0	0	0	0
Bushia sp.	M	1	0	0	0	0	0	1	0	0	0	0
Cabira incerta	P	2	0	1	0	0	0	1	0	0	0	0
Caecum pulchellum	M	7	0	3	0	0	0	3	1	0	0	0

Appendix 3. Total abundance (#/ $0.04m^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Caecum sp.	M	8	0	4	3	0	1	0	0	0	0	0
Callianassidae	O	1	0	0	0	0	0	0	0	0	1	0
Calyptraea centralis	M	3	0	1	2	0	0	0	0	0	0	0
Campylaspis sp.	O	28	0	0	5	1	0	0	0	0	20	2
Capitella capitata	P	1	1	0	0	0	0	0	0	0	0	0
Capitella jonesi	P	1	0	1	0	0	0	0	0	0	0	0
Capitellidae	P	24	1	12	2	0	0	5	2	0	2	0
Capitellidae sp. A	P	1	0	0	0	0	0	0	0	0	0	1
Cardiomya ornatissima	M	1	0	0	0	0	0	1	0	0	0	0
Carinomella lactea	O	28	2	5	0	3	0	5	1	0	10	2
Caulleriella sp.	P	30	2	8	6	4	0	2	0	0	5	3
Cerapus tubularis	A	31	0	0	0	0	1	6	4	0	18	2
Ceratonereis irritabilis	P	7	0	0	0	0	0	0	1	0	6	0
Chaetozone sp.	P	11	0	0	8	1	0	0	0	0	1	1
Chione latilirata	M	1	0	0	0	0	0	0	1	0	0	0
Chione sp.	M	1	0	0	1	0	0	0	0	0	0	0
Chiridotea sp.	O	1	1	0	0	0	0	0	0	0	0	0
Chiridotea stenops	O	16	0	0	0	0	3	3	3	2	0	5
Chrysopetalidae	P	2	0	0	2	0	0	0	0	0	0	0
Cirratulidae	P	27	2	5	3	1	2	3	0	1	9	1
Cirriformia sp.	P	50	7	5	15	4	2	4	2	2	6	3
Cirrophorus sp.	P	20	2	6	0	0	0	0	0	0	12	0
Corbula contracta	M	1	0	0	0	0	0	0	0	0	1	0
Corbula sp.	M	1	0	0	0	0	0	0	0	0	1	0
Corophiidae	A	2	0	2	0	0	0	0	0	0	0	0
Corophium sp.	A	1	0	0	0	0	0	0	0	0	1	0
Crangonidae	O	1	0	0	0	0	0	0	0	0	0	1
Crassinella lunulata	M	128	0	76	9	2	1	19	2	4	15	0
Crassinella martinicensis	M	137	33	36	44	6	1	3	1	12	1	0
Crepidula fornicata	M	7	0	0	0	0	0	0	0	0	7	0
Crepidula sp.	M	6	1	1	1	0	0	1	0	0	2	0
Crepidulidae	M	1	0	1	0	0	0	0	0	0	0	0
Cumacea	O	13	1	3	1	2	0	1	2	1	2	0
Cumacean sp. A	O	1	0	0	0	0	0	0	0	0	1	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Cyathura burbancki	O	30	1	24	1	0	1	0	0	3	0	0
Cyclaspis sp.	O	127	2	2	2	9	2	37	35	0	27	11
Cylichnella bidentata	M	32	0	0	0	0	0	11	5	0	12	4
Dentalium sp.	M	2	0	1	0	1	0	0	0	0	0	0
Diogenidae	O	2	0	0	0	0	2	0	0	0	0	0
Diopatra cuprea	P	5	0	3	0	0	0	0	1	0	1	0
Dipolydora sp.	P	1	1	0	0	0	0	0	0	0	0	0
Dispio uncinata	P	15	0	0	0	3	0	0	5	1	6	0
Dissodactylus mellitae	O	21	0	0	0	0	2	0	8	11	0	0
Dorvilleidae	P	110	6	29	48	9	3	0	0	0	15	0
Dosinia elegans	M	7	0	3	0	0	0	1	0	0	3	0
Drilonereis sp.	P	1	0	0	0	0	0	0	1	0	0	0
Echinoidea	O	1	0	0	0	0	0	1	0	0	0	0
Echiura	O	1	0	1	0	0	0	0	0	0	0	0
Edotea montosa	O	5	0	0	0	1	0	2	0	0	2	0
Edotea triloba	O	3	0	0	0	0	0	0	0	0	3	0
Elasmopus levis	A	1	0	0	0	0	0	0	0	1	0	0
Emerita benedicti	O	1	0	0	0	0	0	0	0	1	0	0
Ensis directus	M	2	0	1	0	1	0	0	0	0	0	0
Eobrolgus spinosus	A	9	0	0	0	0	0	3	0	0	4	2
Epitoniidae	M	1	0	1	0	0	0	0	0	0	0	0
Epitonium sp.	M	1	0	0	0	0	0	0	0	0	1	0
Ervilia concentrica	M	1	0	0	0	1	0	0	0	0	0	0
Eteone lactea	P	3	0	1	1	0	1	0	0	0	0	0
Euceramus praelongus	O	8	0	0	4	1	0	0	0	0	3	0
Eudevenopus honduranus	A	334	19	65	54	82	12	15	36	15	8	28
Eulalia sanguinea	P	12	0	4	3	0	0	0	0	0	5	0
Eulalia sp.	P	1	1	0	0	0	0	0	0	0	0	0
Eunice vittata	P	1	0	0	1	0	0	0	0	0	0	0
Eurydice littoralis	O	18	3	0	8	7	0	0	0	0	0	0
Eurydice piperata	O	1	0	0	1	0	0	0	0	0	0	0
Euryplax nitida	O	1	0	0	1	0	0	0	0	0	0	0
Eurythoe sp.	P	6	1	5	0	0	0	0	0	0	0	0
Exogone sp.	P	20	2	10	5	1	0	0	0	0	2	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Gammaridea	A	9	1	2	2	0	0	0	0	1	2	1
Gastrochaena hians	M	1	0	1	0	0	0	0	0	0	0	0
Gastropoda	M	20	3	7	0	2	2	0	1	2	3	0
Gibberosus myersi	A	4	0	0	0	4	0	0	0	0	0	0
Glottidia pyramidata	O	29	2	10	1	3	2	5	0	0	5	1
Glycera americana	P	9	1	1	0	1	0	2	0	0	4	0
Glycera oxycephala	P	91	9	14	37	5	10	0	0	13	0	3
Glycera papillosa	P	8	0	0	8	0	0	0	0	0	0	0
Glycera robusta	P	2	0	0	0	1	0	0	1	0	0	0
Glycera sp.	P	84	21	9	11	17	3	10	4	3	5	1
Glycerea	P	6	1	3	2	0	0	0	0	0	0	0
Goneplacidae	O	6	0	3	1	1	0	0	0	0	1	0
Goniada littorea	P	198	6	11	9	12	13	22	38	6	42	39
Goniadidae	P	27	6	19	2	0	0	0	0	0	0	0
Goniadides carolinae	P	115	0	34	20	0	0	0	0	1	60	0
Hargeria rapax	O	1	0	1	0	0	0	0	0	0	0	0
Harmothoe sp.	P	15	0	3	1	0	0	0	0	0	11	0
Haustoriidae	A	2	0	0	1	1	0	0	0	0	0	0
Hepatus pudibundus	O	8	0	4	0	0	0	0	1	1	2	0
Hesionidae	P	38	5	11	11	0	0	0	0	4	7	0
Hesionura sp.	P	65	15	0	47	3	0	0	0	0	0	0
Heterocrypta granulata	O	3	0	2	0	0	0	0	1	0	0	0
Heteropodarke heteromorpha	P	13	2	2	4	3	0	1	0	1	0	0
Heteropodarke sp.	P	1	0	0	0	0	0	1	0	0	0	0
Hippomedon serratus	A	1	0	1	0	0	0	0	0	0	0	0
Holothuroidea	O	2	1	1	0	0	0	0	0	0	0	0
Holothuroidea sp. A	O	1	0	0	0	0	0	1	0	0	0	0
Hydroides microtis	P	59	0	37	18	2	0	0	0	2	0	0
Hydroides sp.	P	2	0	2	0	0	0	0	0	0	0	0
Idoteidae	O	1	0	0	0	1	0	0	0	0	0	0
Isolda pulchella	P	11	0	5	1	2	0	1	0	0	2	0
Kinbergonuphis sp.	P	17	2	4	1	4	2	2	1	1	0	0
Laonice cirrata	P	9	0	6	0	0	0	0	0	0	3	0
Latreutes parvulus	O	2	0	0	0	0	0	0	0	0	2	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Leitoscoloplos sp.	P	1	0	0	1	0	0	0	0	0	0	0
Lembos sp.	A	1	0	0	0	0	0	0	0	1	0	0
Lepidopa websteri	O	1	0	0	0	0	0	0	1	0	0	0
Leptochela papulata	O	5	0	0	0	0	0	1	0	0	3	1
Leptochela serratorbita	O	14	0	2	1	2	0	1	2	0	5	1
Leptognathia caeca	O	14	0	1	7	5	1	0	0	0	0	0
Leptonacea sp.	M	3	0	0	0	0	0	3	0	0	0	0
Leptosynapta sp.	O	1	0	0	0	0	0	0	0	0	1	0
Leptosynapta tenuis	O	38	8	3	18	2	0	2	0	2	1	2
Liljiborgiidae	A	1	0	0	0	1	0	0	0	0	0	0
Limopsis sp.	M	1	0	0	1	0	0	0	0	0	0	0
Listriella barnardi	A	9	1	0	0	0	0	3	2	0	3	0
Listriella clymenellae	A	2	0	0	0	0	2	0	0	0	0	0
Loimia medusa	P	3	0	0	0	0	0	1	1	0	1	0
Lucifer faxoni	O	6	1	1	0	2	1	0	0	0	1	0
Luconacia incerta	A	6	0	0	1	2	1	0	0	0	0	2
Luidia clathrata	O	1	0	0	0	0	1	0	0	0	0	0
Lumbrineridae	P	3	0	1	0	0	0	0	0	0	2	0
Lumbrinerides sp.	P	9	0	0	6	3	0	0	0	0	0	0
Lumbrineris cruzensis	P	91	3	35	6	12	3	10	6	0	12	4
Lumbrineris sp.	P	1	0	0	0	0	0	0	0	0	0	1
Lysianassidae	A	1	0	0	0	0	0	0	0	0	0	1
Lysilla sp.	P	1	0	0	1	0	0	0	0	0	0	0
Macoma tenta	M	2	0	0	0	0	0	0	1	1	0	0
Macroclymene sp.	P	5	0	5	0	0	0	0	0	0	0	0
Maera caroliniana	A	7	0	3	4	0	0	0	0	0	0	0
Magelona sp.	P	407	3	5	3	2	9	133	15	5	209	23
Majidae	O	1	0	0	0	0	0	0	0	0	1	0
Malacoceros vanderhorsti	P	3	0	3	0	0	0	0	0	0	0	0
Maldanidae	P	9	0	4	3	0	0	1	0	0	1	0
Marphysa sanguinea	P	1	0	0	1	0	0	0	0	0	0	0
Mediomastus ambiseta	P	112	0	31	1	0	0	0	11	2	57	10
Mediomastus californiensis	P	222	14	144	21	0	2	0	0	2	39	0
Mediomastus sp.	P	348	7	113	22	3	1	0	3	2	192	5

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Megalomma lobiferum	P	1	0	1	0	0	0	0	0	0	0	0
Melanellidae	M	14	0	0	8	0	0	0	2	0	1	3
Melita nitida	A	3	0	0	3	0	0	0	0	0	0	0
Melita sp.	A	1	0	1	0	0	0	0	0	0	0	0
Melitidae	A	1	0	0	0	0	0	0	0	0	1	0
Melitidae sp. A	A	7	0	4	0	0	0	0	0	0	3	0
Mellita quinquesperforata	O	3	0	0	0	0	1	0	0	2	0	0
Mellita sp.	O	222	82	1	65	11	22	3	2	17	0	19
Metapenaeopsis goodei	O	12	0	0	2	3	1	2	0	1	1	2
Metharpinia floridana	A	41	3	26	3	6	1	2	0	0	0	0
Microphthalmus sp.	P	2	0	0	2	0	0	0	0	0	0	0
Microprotopus raneyi	A	11	0	0	0	0	0	0	7	0	4	0
Microspio pigmentata	P	3	1	1	0	0	0	0	0	0	1	0
Moira atropos	O	2	0	0	0	0	0	1	1	0	0	0
Monoculodes edwardsi	A	1	0	0	0	0	0	0	0	0	1	0
Mooreonuphis nebulosa	P	1	0	0	0	0	0	1	0	0	0	0
Musculus lateralis	M	1	0	1	0	0	0	0	0	0	0	0
Myriochele oculata	P	253	1	66	10	21	0	17	36	2	57	43
Myriochele sp.	P	2	2	0	0	0	0	0	0	0	0	0
Mystides borealis	P	2	1	0	0	0	0	0	0	0	1	0
Nassarina glypta	M	18	1	4	2	3	1	3	4	0	0	0
Natica pusilla	M	149	11	20	19	12	9	24	24	7	16	7
Naticidae	M	5	0	0	1	0	0	2	1	0	1	0
Nematonereis hebes	P	2	0	0	1	0	0	0	0	0	1	0
Nemertinea	O	653	49	96	53	54	18	128	60	15	136	44
Neopanope sayi	O	1	0	0	0	0	0	0	1	0	0	0
Nephtyidae	P	3	2	1	0	0	0	0	0	0	0	0
Nephtys picta	P	93	4	7	7	21	15	6	6	8	3	16
Nephtys simoni	P	40	7	4	4	8	3	0	6	3	0	5
Nephtys sp.	P	13	0	0	1	0	8	0	0	4	0	0
Nereidae	P	41	1	20	1	0	0	6	5	0	8	0
Nereis acuminata	P	5	0	3	0	0	0	0	2	0	0	0
Nereis lamellosa	P	1	0	0	0	0	0	0	1	0	0	0
Nereis micromma	P	1	0	0	0	0	0	0	0	1	0	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Nereis sp.	P	2	0	0	0	0	0	0	0	1	1	0
Nereis succinea	P	2	0	2	0	0	0	0	0	0	0	0
Notomastus hemipodus	P	2	0	0	0	1	0	1	0	0	0	0
Notomastus latericeus	P	8	0	0	0	0	0	0	0	0	0	8
Notomastus sp.	P	5	0	1	0	0	0	3	1	0	0	0
Nucula sp.	M	11	0	1	1	0	0	3	0	0	6	0
Odontosyllis enopla	P	4	0	1	2	0	0	0	0	0	1	0
Ogyrides alphaerostris	O	13	2	0	0	2	1	1	3	0	3	1
Ogyrides hayi	O	1	0	0	0	0	0	0	0	1	0	0
Oligochaeta	O	181	12	50	30	37	5	8	2	1	28	8
Olivella mutica	M	1	0	0	0	0	1	0	0	0	0	0
Olivella sp.	M	11	0	0	0	0	0	2	0	0	6	3
Olividae	M	12	2	0	0	3	1	3	0	1	2	0
Onuphidae	P	6	3	0	0	1	1	0	1	0	0	0
Onuphis eremita	P	7	2	1	0	0	0	1	2	0	0	1
Ophelia denticulata	P	2	0	0	0	0	0	0	0	0	0	2
Opheliidae	P	13	0	4	3	0	0	2	2	0	1	1
Ophelina denticulata	P	9	0	0	9	0	0	0	0	0	0	0
Ophelina sp.	P	1	0	0	1	0	0	0	0	0	0	0
Ophiuroidea	O	197	8	10	97	20	1	18	5	2	30	6
Ovalipes stephensoni	O	1	0	0	0	1	0	0	0	0	0	0
Owenia fusiformis	P	107	4	15	13	15	5	13	6	3	28	5
Oxyurostylis smithi	O	120	0	1	4	7	0	19	29	4	35	21
Paguridae	O	2	1	0	0	0	0	0	1	0	0	0
Paguridea	O	15	0	0	2	2	1	1	0	3	6	0
Pagurus hendersoni	O	1	0	1	0	0	0	0	0	0	0	0
Pagurus longicarpus	O	17	1	10	0	0	0	4	2	0	0	0
Pagurus sp.	O	10	0	0	0	1	3	0	0	3	3	0
Paleanotus sp.	P	1	0	0	1	0	0	0	0	0	0	0
Paracaprella sp.	A	1	0	0	0	0	0	0	1	0	0	0
Paracaprella tenuis	A	3	0	0	0	3	0	0	0	0	0	0
Paraonidae	P	5	1	1	0	0	0	0	0	0	3	0
Paraonis fulgens	P	32	13	0	6	2	7	0	0	1	0	3
Paraonis pygoenigmatica	P	4	0	0	3	1	0	0	0	0	0	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Parapionosyllis longicirrata	P	2	0	0	0	2	0	0	0	0	0	0
Parapionosyllis sp.	P	33	3	5	21	3	0	0	0	0	1	0
Paraprionospio pinnata	P	41	0	4	0	2	1	15	6	0	10	3
Parvilucina multilineata	M	126	16	15	2	5	4	23	19	1	32	9
Pelecypoda	M	121	4	17	15	2	10	20	3	4	42	4
Pelecypoda sp. A	M	45	13	2	2	0	0	8	6	0	14	0
Pelecypoda sp. B	M	92	9	16	26	24	3	0	6	4	3	1
Pelecypoda sp. C	M	13	0	13	0	0	0	0	0	0	0	0
Pelecypoda sp. D	M	1	0	1	0	0	0	0	0	0	0	0
Pelecypoda sp. E	M	1	0	1	0	0	0	0	0	0	0	0
Pelecypoda sp. F	M	5	0	4	0	1	0	0	0	0	0	0
Pelecypoda sp. G	M	4	0	0	0	0	0	0	0	0	4	0
Pelecypoda sp. H	M	1	0	0	0	0	0	0	0	0	1	0
Pelecypoda sp. I	M	1	0	0	0	0	0	0	0	0	1	0
Persephona mediterranea	O	6	1	1	0	0	0	1	1	1	0	1
Petaloproctus sp.	P	2	0	2	0	0	0	0	0	0	0	0
Pholoe minuta	P	1	0	1	0	0	0	0	0	0	0	0
Phoronida	O	7	2	0	0	0	0	4	0	0	1	0
Photis sp.	A	1	0	0	0	0	0	0	0	0	1	0
Phoxocephalidae	A	2	0	0	0	0	0	1	1	0	0	0
Phyllodoce arenae	P	10	0	1	2	2	1	0	0	1	2	1
Phyllodoce groenlandica	P	8	0	1	0	4	0	0	0	0	3	0
Phyllodoce sp.	P	3	0	3	0	0	0	0	0	0	0	0
Phyllodocidae	P	32	0	20	3	0	0	0	0	0	9	0
Phylo felix	P	1	0	0	0	0	0	0	0	0	0	1
Pilargidae	P	1	0	0	0	0	1	0	0	0	0	0
Pinnixa sp.	O	13	1	0	0	0	1	5	1	1	3	1
Pionosyllis gesae	P	83	19	11	47	3	2	0	0	0	1	0
Pionosyllis sp.	P	1	0	0	0	0	0	0	0	0	1	0
Pisione remota	P	51	0	2	23	10	0	0	0	0	16	0
Pista cristata	P	2	0	2	0	0	0	0	0	0	0	0
Pitar sp.	M	1	0	0	0	0	0	0	1	0	0	0
Plakosyllis quadrioculata	P	14	0	0	13	1	0	0	0	0	0	0
Plakosyllis sp.	P	1	0	0	0	0	0	0	0	0	1	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Podarke sp.	P	2	0	2	0	0	0	0	0	0	0	0
Podarkeopsis levifuscina	P	13	0	4	5	0	0	0	0	0	4	0
Poecilochaetus johnsoni	P	1	0	0	1	0	0	0	0	0	0	0
Polychaeta sp. A	P	1	1	0	0	0	0	0	0	0	0	0
Polychaeta sp. B	P	1	1	0	0	0	0	0	0	0	0	0
Polychaete sp. C	P	18	0	0	18	0	0	0	0	0	0	0
Polycirrus sp.	P	10	3	6	0	0	0	0	0	1	0	0
Polydora cornuta	P	1	1	0	0	0	0	0	0	0	0	0
Polydora socialis	P	16	0	8	0	0	0	0	0	5	3	0
Polydora sp.	P	3	0	1	0	0	0	2	0	0	0	0
Polygordiidae	O	404	23	81	27	99	18	54	28	3	54	17
Polynoidae	P	7	0	0	0	1	0	0	0	3	0	3
Pomatoceros americanus	P	1	0	0	0	1	0	0	0	0	0	0
Portunidae	O	6	0	0	2	0	0	0	2	0	1	1
Portunus sayi	O	1	0	0	1	0	0	0	0	0	0	0
Prionospio cirrifera	P	48	0	27	11	2	0	3	0	1	4	0
Prionospio cirrobranchiata	P	14	0	1	0	0	1	0	0	0	12	0
Prionospio cristata	P	965	33	300	309	35	12	9	34	32	192	9
Prionospio dayi	P	1231	51	135	59	181	140	166	186	42	141	130
Prionospio sp.	P	465	9	232	81	5	3	5	8	17	103	2
Prionospio sp. A	P	3	0	0	0	0	0	3	0	0	0	0
Processa sp.	O	10	0	1	0	2	0	1	0	1	4	1
Protohaustorius deichmannae	A	320	29	14	26	30	30	20	67	33	4	67
Ptilanthura tenuis	O	2	0	1	0	0	0	0	1	0	0	0
Pyramidellidae	M	1	0	0	0	0	0	1	0	0	0	0
Rhepoxynius epistomus	A	727	70	31	127	175	72	33	74	57	17	71
Rhepoxynius hudsoni	A	3	0	0	0	0	0	0	0	0	3	0
Sabellaria sp.	P	13	0	0	0	0	0	8	0	0	4	1
Sabellaria vulgaris	P	691	0	375	0	13	1	0	24	2	276	0
Sabellariidae	P	441	0	415	2	0	0	11	0	12	1	0
Saccocirridae	P	10	1	0	3	0	0	0	0	0	6	0
Scolecolepides viridis	P	1	0	0	1	0	0	0	0	0	0	0
Scolelepis sp.	P	1	0	0	0	0	0	0	0	0	1	0
Scolelepis squamata	P	7	1	3	0	2	0	1	0	0	0	0

Appendix 3. Total abundance (#/ 0.04m^2) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Scolelepis texana	P	6	0	1	0	1	1	0	0	1	2	0
Scoletoma ernesti	P	2	0	0	0	0	0	0	0	0	2	0
Scoletoma tenuis	P	49	0	29	0	6	0	2	0	0	11	1
Scoloplos rubra	P	10	1	2	0	0	0	0	2	2	0	3
Serpula vermicularis granulosa	P	45	0	9	35	1	0	0	0	0	0	0
Serpulidae	P	51	3	41	4	1	0	0	0	0	2	0
Serpulidae sp. A	P	3	0	0	3	0	0	0	0	0	0	0
Sigambra bassi	P	8	0	7	0	0	1	0	0	0	0	0
Sigambra sp.	P	6	1	2	0	0	0	0	0	0	3	0
Sigambra tentaculata	P	21	0	0	0	1	0	11	2	0	7	0
Simnia sp.	M	1	0	0	0	0	0	0	0	0	1	0
Sipuncula	O	25	0	6	4	0	0	2	0	0	13	0
Solenidae	M	1	0	1	0	0	0	0	0	0	0	0
Sphaerosyllis aciculata	P	12	0	4	8	0	0	0	0	0	0	0
Sphaerosyllis glandulata	P	1	0	1	0	0	0	0	0	0	0	0
Sphaerosyllis sp.	P	7	1	2	1	3	0	0	0	0	0	0
Sphaerosyllis taylori	P	2	0	0	0	2	0	0	0	0	0	0
Spio pettiboneae	P	9	0	0	3	0	0	0	1	1	4	0
Spiochaetopterus costarum oculatus	P	3	0	0	0	0	0	0	2	0	1	0
Spionidae	P	18	2	3	1	0	0	1	0	1	10	0
Spionidae sp. A	P	1	0	1	0	0	0	0	0	0	0	0
Spiophanes bombyx	P	36	1	7	2	4	10	4	3	1	2	2
Spiophanes missionensis	P	28	0	8	2	0	0	6	1	0	11	0
Spiophanes sp.	P	1	0	0	0	0	0	0	1	0	0	0
Spiophanes sp. A	P	1	0	0	0	0	0	0	0	0	1	0
Spisula solidissima	M	7	1	1	0	0	0	5	0	0	0	0
Sthenelais boa	P	2	0	0	0	0	0	2	0	0	0	0
Sthenelais limicola	P	4	0	0	1	0	0	0	0	0	3	0
Sthenelais sp.	P	1	0	0	0	0	0	1	0	0	0	0
Streptosyllis sp.	P	15	2	1	7	4	0	0	1	0	0	0
Strigilla mirabilis	M	75	12	7	17	9	13	6	3	6	0	2
Syllidae	P	38	8	8	20	0	0	0	0	0	2	0
Syllidae sp. A	P	1	0	0	0	1	0	0	0	0	0	0
Syllides floridanus	P	1	0	0	1	0	0	0	0	0	0	0

Appendix 3. Total abundance (#/ $0.04m^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

Species Name	Taxon	Total Abund.	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Syllides fulvus	P	1	0	1	0	0	0	0	0	0	0	0
Syllides sp.	P	3	0	0	1	2	0	0	0	0	0	0
Syllis prolifera	P	4	0	2	2	0	0	0	0	0	0	0
Syllis sp.	P	4	0	1	3	0	0	0	0	0	0	0
Synchelidium americanum	A	118	1	7	3	7	3	27	29	1	37	3
Synelmis ewingi	P	174	0	0	0	0	0	0	0	4	170	0
Tanaidacea	O	9	0	2	3	4	0	0	0	0	0	0
Tanaidacea sp. A	O	4	0	0	4	0	0	0	0	0	0	0
Tanaissus psammophilus	O	14	14	0	0	0	0	0	0	0	0	0
Tellina agilis	M	48	3	14	2	5	1	15	2	3	1	2
Tellina alternata	M	3	0	0	0	0	3	0	0	0	0	0
Tellina iris	M	4	0	0	0	0	0	0	0	1	0	3
Tellina probrina	M	29	4	0	9	15	0	0	0	0	0	1
Tellina sp.	M	64	2	13	9	26	5	0	4	3	0	2
Tellinidae	M	121	5	1	14	0	4	8	17	1	66	5
Terebellidae	P	5	1	0	3	0	0	0	0	0	1	0
Tharyx acutus	P	52	3	34	2	3	3	1	2	3	1	0
Tiron sp.	A	5	0	0	0	0	0	2	1	0	1	1
Tiron triocellatus	A	45	0	3	0	4	3	1	4	3	26	1
Tiron tropakis	A	34	8	5	2	1	6	3	2	4	3	0
Travisia sp.	P	1	0	0	0	0	0	0	0	0	0	1
Turbonilla sp.	M	38	0	2	7	8	2	3	8	1	5	2
Turridae	M	10	0	2	0	2	2	3	0	0	0	1
Typosyllis sp.	P	1	0	0	1	0	0	0	0	0	0	0
Unciola sp.	A	2	0	0	0	0	0	0	0	0	2	0
Upogebia affinis	O	2	0	1	0	0	0	0	0	0	1	0
Websterinereis tridentata	P	25	0	0	0	0	1	0	0	0	24	0
Total number of individuals		15759	990	3729	2192	1402	632	1194	1088	566	3141	825
Total number of species		402	127	207	166	137	96	127	118	101	187	96